

INSTRUCTION MANUAL

FOR

B & K/PRECISION

MODEL 1470

TRIGGERED SWEEP

DUAL TRACE

OSCILLOSCOPE



BK PRECISION

6470 W. Cortland St.
Chicago, IL 60635

INTRODUCTION

The B & K Precision Model 1470 Triggered Sweep Dual Trace Oscilloscope is a laboratory quality, professional instrument for observing and measuring waveforms in electronic circuits. Dual vertical inputs are provided for simultaneous viewing of two waveforms. Either input or both can be viewed as desired. A Chop mode is provided for simultaneous viewing of low frequency, low repetition-rate waveforms, and Alternate mode operation is provided for simultaneous viewing of high speed, high repetition rate

waveforms. In addition, the two input signals can be added or, by using the Normal/Invert function for Channel 2, the difference of two given waveforms can also be observed. The dual trace feature, together with the bandwidth, sweep speed and sensitivity provided, make this the ideal oscilloscope for trouble-shooting and repairing electronic equipment as well as for research and development work and laboratory instruction.

FEATURES

DUAL TRACE

Two input waveforms can be viewed either singly or simultaneously as desired. Individual vertical sensitivity and positioning controls are provided for completely independent adjustment of the two signal amplitudes.

FULLY SOLID STATE

Only the cathode ray tube uses a filament. All other stages use transistors, diodes, and FET's (field effect transistors). Among the advantages of solid state construction are:

- No stabilization warm-up time required.
- Low power drain.
- Dependability—reliability.
- Ruggedness.
- Light Weight.
- Compactness.

TRIGGERED SWEEP

The stability of waveform presentations is beyond comparison with non-triggered sweep oscilloscopes. The sweeps remain at rest until triggered by the signal being observed to assure that they are always synchronized. Fully adjustable trigger threshold allows the desired portion of the waveforms to be used for triggering. The triggering circuits are designed so that either of the two traces can be selected and synchronized with the signal displayed on the respective input channel. If desired, both waveforms can be synchronized to the signal displayed on channel 1. In addition, both displays can be synchronized to an external input trigger.

LARGE SCREEN

The 130 mm (approx. 5.1 inches) diameter cathode ray tube gives easy-to-read presentation.

CALIBRATED VOLTAGE SCALES

Accurate measurement of instantaneous voltages on 11 different attenuator ranges for both Channel 1 and Channel 2.

CALIBRATED SWEEP SPEED

Accurate time measurements on 16 different ranges.

TV HORIZONTAL

Special sync and sweep speed positions specifically designed for observing television horizontal lines.

TV VERTICAL

Special sync sweep speed positions specifically designed for observing television vertical frames.

VECTORSCOPE

Vectorscope inputs and controls on the front panel, plus a vector overlay supplied with the oscilloscope provide a color demodulator display exactly as specified by color television manufacturers.

WIDE BANDWIDTH

DC to 10 MHz bandwidth and 35 nSEC rise time give distortion free, high resolution presentation at high frequencies.

WIDE RANGE OF SWEEP SPEED

Sweep speeds of 1 μ SEC/cm to 0.1 SEC/cm provides every speed necessary for viewing waveforms from DC to 10 MHz.

EXPANDED SCALE

A five time magnification (5X) of the horizontal sweep allows close-up examination of a portion of the waveform. In addition, the 5X magnification provides a maximum sweep speed of 0.2 μ SEC/cm.

HIGH SENSITIVITY

Allows the low capacitance, high impedance, 10:1 attenuation probes to be used for virtually all measurements, thus offering less circuit loading.

CALIBRATION SOURCE

A built-in calibrated 1 volt peak-to-peak square wave permits checking and recalibration of the vertical amplifiers without additional equipment.

ILLUMINATED SCALE

Fully variable illumination for the scale. Vertical and horizontal markers on the scale make voltage and time measurements easy to read.

Z-AXIS INPUT

Intensity modulation capability included for time or frequency markers.

SPECIFICATIONS

VERTICAL AMPLIFIERS (CH 1 and CH 2)

Deflection Factor 0.01 V/cm to 20 V/cm, \pm 5%, in 11 ranges each providing means for fine adjustment.

Frequency Response DC: DC to 10 MHz (-3 dB).
AC: 2 Hz to 10 MHz (-3 dB).

Risetime 35 nanoseconds

Overshoot 3% or less

Input Resistance 1 Megohm (approximate)

Input Capacity 35pF (approximate)

Tilt 5% or less

Max. Input Voltage 300 V (DC + AC peak) or 600 Vp-p

Operating Modes Channel 1 only
Channel 2 only
Alternate (Channel 1 and Channel 2)
Chopped (Channel 1 and Channel 2)
Add (Channel 1 and Channel 2)
Channel 2 invert or normal (push-push switch)

SWEEP CIRCUIT (Common to CH1 and CH2)

Sweep System Triggered and Automatic

Sweep Time 1.0 μ SEC/cm to 0.1 SEC/cm (\pm 5%), in 16 ranges each providing means for fine adjustment.

TVH (13 μ SEC/cm) and TVV (3.6 mSEC/cm)

Sweep Magnification Obtained by enlarging the above sweep 5 times from center. This increases the maximum sweep speed by a factor of five to 0.2 μ SEC/CM.

TRIGGERING

Sync Normal, TVH and TVV

Source Internal, Channel 1, & External

Slope Positive and Negative

Range 20 hertz to 10 megahertz (at minimum of 10 millimeters of deflection, as measured on cathode ray tube).

TV Sync HORIZONTAL—100 Hz to 1 MHz minimum 10 mm of deflection.
VERTICAL—100 Hz to 3 KHz minimum 10mm of deflection.
Any portion of complex TV waveforms can be synchronized and expanded for viewing.

HORIZONTAL AMPLIFIER

Deflection Factor ... 300 mV/cm

Frequency Response DC to 800 KHz (-3 dB)

Input Resistance 100K ohm (Approximately)

Input Capacity 40pF or less

CALIBRATION VOLTAGE

Line freq: square wave of 1Vp-p (\pm 5%)

INTENSITY MODULATION

Voltage 30Vp-p minimum

POWER REQUIREMENTS

117 VAC, 50/60 Hz, 20W
(3 wire line cord)

SEMICONDUCTOR COMPLEMENT

13 FET's
40 Transistors
27 Diodes

ACCESSORIES

Mylar Vector Overlay

Instruction Manual, Schematic and Parts List

Probe Assemblies (not included):

PR-16, Combination 10:1 and Direct Probe

PR-20, Combination 10:1 and Direct Probe

Input Impedance (PR-16 and PR-20)

10:1 (Low Capacity)—10 MEG Ω , 18pF

Direct—1 MEG Ω , 120 pF

Cable Connector—UHF Male

CLP-18 Clip-on tip assembly (Supplied with PR-20 probe)

The CLP-18 assembly is available separately and is interchangeable with the PR-16 tip assembly.

The probe assemblies are illustrated in Figure 3 of the text.

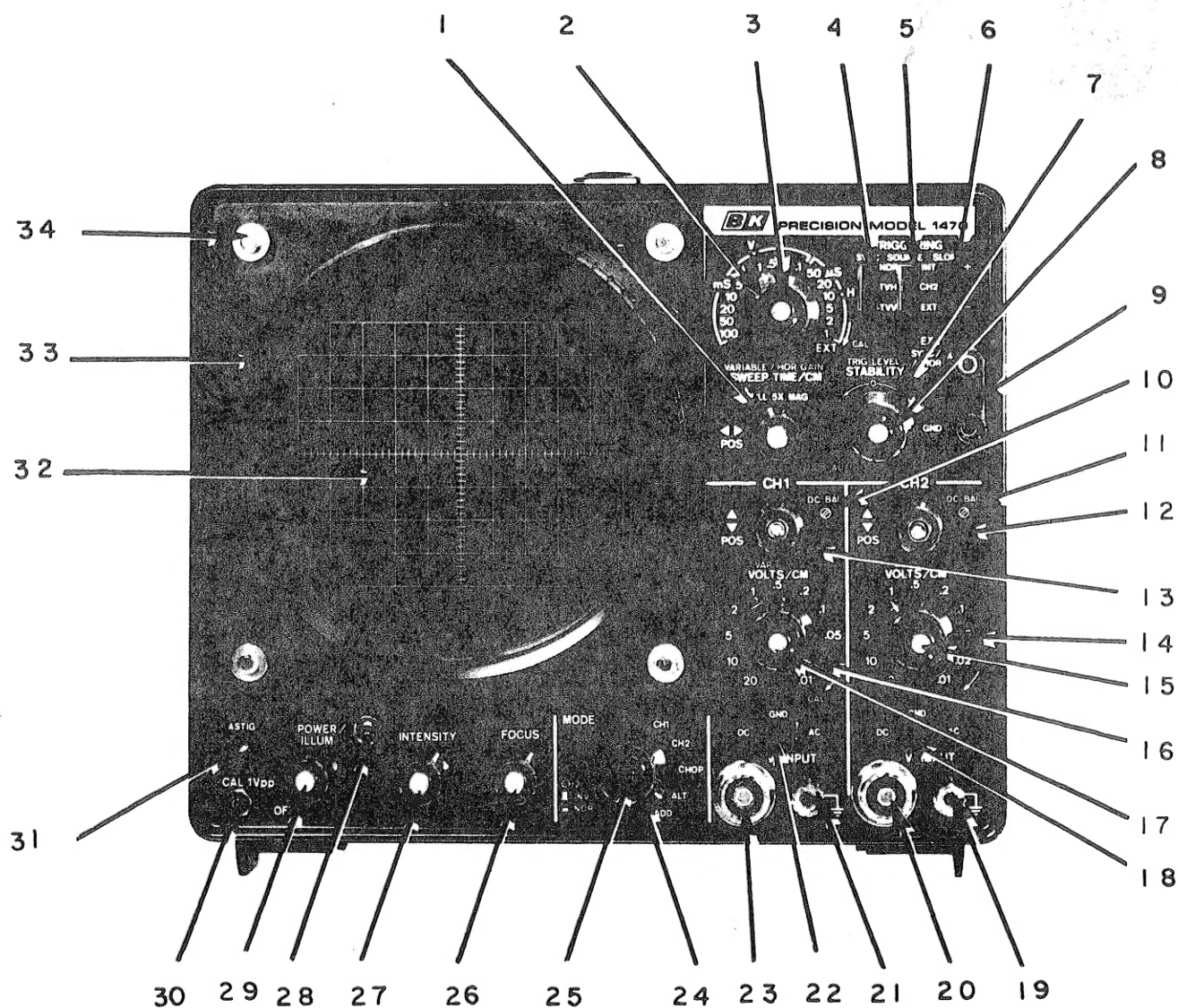


Figure 1. Operator's Controls, Indicators and Facilities

OPERATOR'S CONTROLS, INDICATORS AND FACILITIES (Figure 1)

- 1 **◄► POSITION** control. Rotation adjusts horizontal position of trace. Push-Pull switch selects 5X magnification when pulled out; normal when pushed in.
- 2 **SWEEP TIME CM** switch. Horizontal coarse sweep time selector. Selects calibrated sweep times of 1.0 μ S CM (microsecond per centimeter) to 0.1 SEC CM in 16 steps when VARIABLE HOR GAIN control 3 is set to the CAL position (fully clockwise to the click stop position). The sweep time selected by this switch applies to both Channel 1 and Channel 2. This switch also selects the proper sweep time for television composite video waveform viewing. When in the EXT position, the internal sweep generator is disabled and an external horizontal input signal can be used to provide horizontal sweep.
- 3 **VARIABLE HOR GAIN** control. Fine sweep time adjustment and horizontal gain adjustment when SWEEP TIME CM switch 2 is in the EXT position. In the extreme clockwise (CAL) position the sweep time is calibrated.
- 4 **TRIGGERING SYNC** switch.
 NOR—normal sync operation
 TVH—syncs on horizontal components of composite video.
 TVV—syncs on vertical component of composite video signal.
- 5 **TRIGGERING SOURCE** switch.
 INT—waveform being observed is used as sync trigger. When dual trace operation of this oscilloscope is employed, the waveforms will tend to sync on the average of the two waveforms displayed.
 CH 1—The sweep is triggered on the Channel 1 signal. This applies whether single or dual trace operation is employed.
 EXT—In this position, and with a triggering signal applied to the EXT SYNC/HOR jack 9 the sweep is synchronized to this external trigger signal. This applies whether single or dual trace operation is employed.
- 6 **TRIGGERING SLOPE** switch. Selects sync polarity (+) or (–).
 (+) Sweep is triggered on positive-going portion of observed waveform.
 (–) Sweep is triggered on negative-going portion of observed waveform.
- 7 **STABILITY** control. Sync stability adjustment.
- 8 **TRIG LEVEL** control. Sync level adjustment determines point on waveform slope where sweep starts. In fully counterclockwise (AUTO) position, sweep is automatically synchronized to the average level of the observed waveform.
- 9 **EXT SYNC/HOR** jack. Input terminals for external sync signal or external horizontal input signal.
- 10 **CH 1 DC BAL** adjustment. Vertical DC balance adjustment for Channel 1.
- 11 **CH 2 DC BAL** adjustment. Vertical DC balance adjustment for Channel 2.
- 12 **CH 2 \blacklozenge POS** control. Vertical position adjustment for Channel 2 waveform display.
- 13 **CH 1 \blacklozenge POS** control. Vertical position adjustment for Channel 1 waveform display.
- 14 **CH 2 VOLTS CM** switch. Vertical attenuator for Channel 2 which provides coarse adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 11 steps from .01 to 20 volts per cm when VARIABLE control 15 is set to the CAL position.
- 15 **CH 2 VARIABLE** control. Vertical attenuator adjustment provides fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.
- 16 **CH 1 VOLTS CM** switch. Vertical attenuator for Channel 1 which provides coarse adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 11 steps from .01 to 20 volts per cm when VARIABLE control 17 is set to the CAL position.
- 17 **CH 1 VARIABLE** control. Vertical attenuator adjustment provides fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.
- 18 **CH 2 AC-GND-DC** switch. Vertical input selector switch.
 AC position—blocks dc component of input signal.
 GND position—opens signal input path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing dc measurements.
 DC position—direct input of ac and dc component.
- 19 **CH 2 GND** terminal. Chassis ground.
- 20 **CH 2 V INPUT** jack. Vertical input signal jack for Channel 2.
- 21 **CH 1 GND** terminal. Chassis ground.
- 22 **CH 1 AC-GND-DC** switch. Vertical input selector switch for Channel 1.
 AC position—blocks dc component of input signal.
 GND position—opens signal input path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing dc measurements.
 DC position—direct input of ac and dc components.
- 23 **CH 1 V INPUT** jack. Vertical input jack for Channel 1.
- 24 **MODE** switch. This switch selects the basic operating modes of the oscilloscope.
 CH 1. Only the input signal to Channel 1 is displayed. Single trace operation is employed in this switch position.
 CH 2. Only the input signal to Channel 2 is displayed.
 CHOP—This mode is used in dual trace operation when low frequency waveforms are displayed using low sweep repetition rates, (less than 0.5 mS per cm).
 ALT—In this position of the MODE switch dual trace operation is obtained in which the sweep for the Channel 1 signal and

that for the Channel 2 signal are alternately displayed. The CHOP and ALT functions are described in greater detail in the OPERATING SECTION of this manual.

ADD—The waveform displays of Channels 1 and 2 can be added and the resultant displayed on the CRT screen as a single trace.

- 25** CH 2 INV NOR switch. This is a push-push switch located in the center of the MODE switch knob **24**. Whenever the Channel 2 display is used (positions CH 2, CHOP, ALT and ADD of MODE switch) this switch can be used to reverse the polarity of the Channel 2 waveform display.
- 26** FOCUS control.
- 27** INTENSITY control. Adjusts brightness of trace.
- 28** Pilot Lamp. Lights when oscilloscope is turned on.
- 29** POWER ILLUM control Fully counterclockwise rotation of this control turns off oscilloscope. Clockwise rotation turns on oscilloscope and provides graticule illumination for the CRT screen. Further clockwise rotation of the control decreases the illumination level.
- 30** CAL 1 V p-p Jack. Provides calibrated 1 V p-p square wave output signal. This is used for

calibration of the vertical amplifier attenuators and to check the frequency compensation adjustments of the probes used with the oscilloscope.

- 31** ASTIG Adjustment. Astigmatism adjustment provides optimum spot roundness when used in conjunction with the intensity and focus controls. Very little re-adjustment of this control is required after initial adjustment.
- 32** Scale. The 8 x 10 cm graticule provides calibration marks for voltage (Vertical) and time (Horizontal) measurements. Scale can be removed and replaced with Vector Overlay **37**.
- 33** Observation Bezel.
- 34** Bezel Retaining Nuts (4). Bezel must be removed to replace 8 x 10 graticule with Vector Overlay for vectorscope operation.
- 35, 36** Probes (See Figure 3). The B & K Model PR16 and PR20 combination 10:1/Direct probes have been designed for use with this oscilloscope. However, any probe designed for use with an oscilloscope having a nominal input impedance of 1 megohm shunted by 35 pf can be used. The range of compensation adjustment should be checked using the CAL 1V p-p jack **30**.
- 37** Vector Overlay (not illustrated).

OTHER OPERATORS FACILITIES (SEE FIGURE 2)

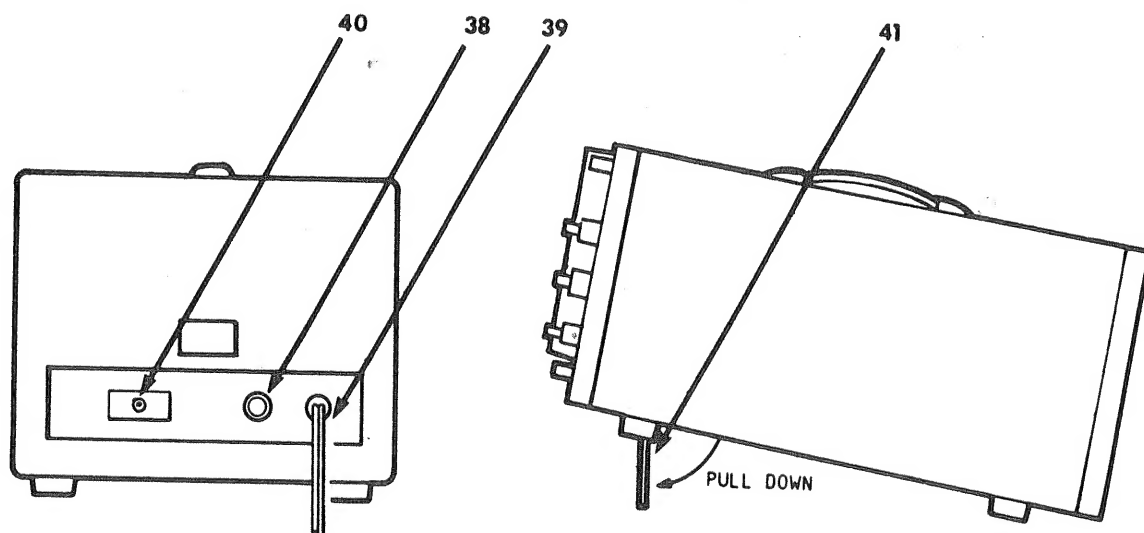


Figure 2. Rear Panel and Side View

- 38** Fuse Holder.
- 39** AC Line Cord.
- 40** INT MOD jack. Intensity modulation (Z axis) input.

- 41** Folding Tilt Stand. With the tilt stand folded up, the scope sits on rubber feet. With the stand unfolded, the front of the scope is elevated to a convenient viewing angle.

OPERATING INSTRUCTIONS

The basic operating instructions for this oscilloscope are divided into two parts. The first describes use of the scope in single trace operation. The second portion describes the use of the oscilloscope in dual trace operation.

CAUTION:

Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The spot may become permanently burned. Reduce intensity or keep the spot in motion by causing it to sweep.

SINGLE TRACE OPERATION.

Either Channel 1 or Channel 2 can be used for single trace operation. For convenience, Channel 2 will be used in the following operating instructions. The advantage of using Channel 2 rather than Channel 1 is that the polarity of the observed waveform can be reversed as desired by use of the CH 2 \blacksquare INV \blacktriangle NOR switch 25.

INITIAL STARTING PROCEDURE

1. Set the POWER/ILLUM control 29 to the OFF position (fully counterclockwise).
2. Connect the power cord to a 117 volt, 60 Hz AC outlet.
3. Set the CH 2 \blacktriangle POS control 12 and \blacktriangleleft POSITION control 1 to the center of their ranges.
4. Set the TRIG LEVEL control 8 to the AUTO position (fully counterclockwise).
5. Set the AC-GND-DC switch 18 to the GND position.
6. Set the MODE switch 24 to the CH 2 position.
7. Turn on the oscilloscope by rotating the POWER/ILLUM control 29 clockwise. It will "click" on and the pilot lamp 28 will light. Turn the control clockwise to the desired scale illumination.
8. Wait a few seconds for the cathode ray tube (CRT) to warm up. A trace should appear on the face of the CRT.

9. If no trace appears, increase (clockwise) the INTENSITY control 27 setting until the trace is easily observed. If trace is still not visible, turn STABILITY control 7 fully clockwise, which places the sweep generator in a free-running mode (no sync trigger required to produce sweep).

10. Adjust the FOCUS control 26 and INTENSITY control 27 for the thinnest, sharpest trace.
11. Readjust the position controls 1 and 12, if necessary to center the trace.
12. Check for proper adjustment of the ASTIG 31 and DC BAL 11 controls and CRT positioning as instructed in the MAINTENANCE and CALIBRATION portion of this manual. These adjustments require checking only periodically.

The oscilloscope is now ready for making waveform measurements.

WAVEFORM OBSERVATION

1. Perform the steps of the initial starting procedure, then connect the probe cable to the CH 2 V INPUT receptacle 20. The following instructions assume the use of the B & K-Precision model PR-16 or PR-20 combination probes.
2. For all except low amplitude waveforms, the probes are set for 10:1 attenuation. For low amplitude waveforms (below 0.5 volt peak-to-peak), set the probe for DIRECT. See Figure 3 for changing the probes from 10:1 to DIRECT, or vice versa. The probe has a 10 megohm input impedance with only 18pF shunt capacitance in the 10:1 position and 1 megohm with 120pF shunt capacitance in the DIRECT position. The higher input impedance (low capacity position) should be used when possible to decrease circuit loading.
3. Set the CH 2 AC-GND-DC switch 18 to AC for measuring only the ac component (This is the normal position for most measurements and must be used if the point being measured in-

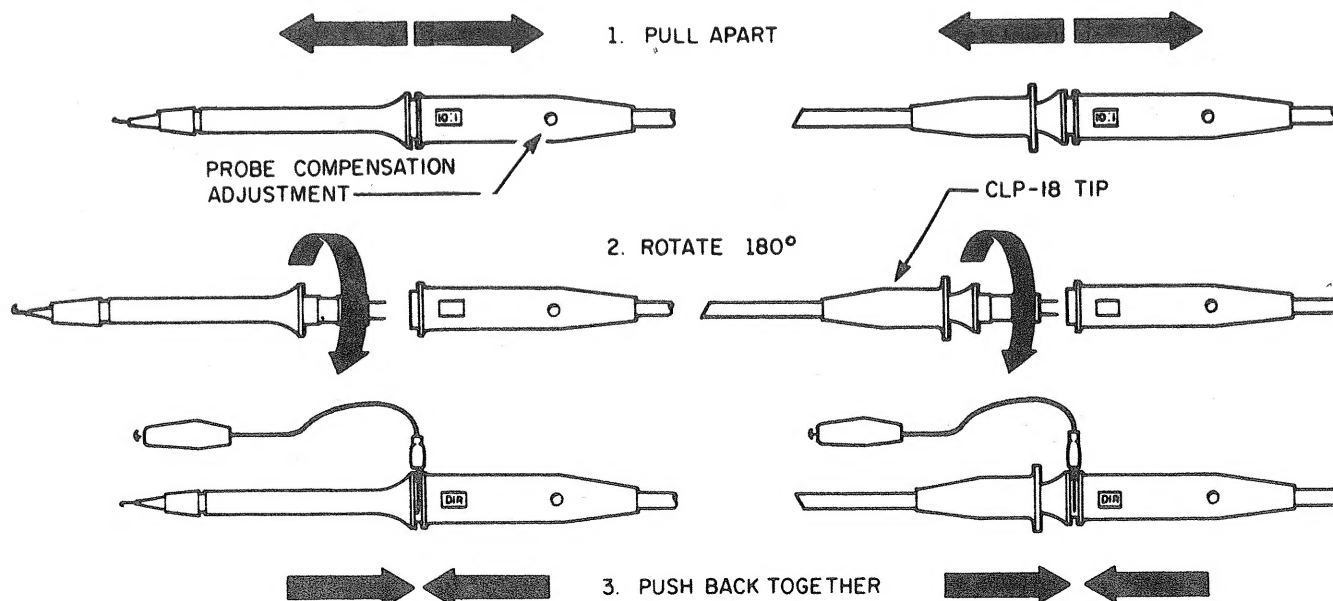


Figure 3. Probe Details

cludes a large dc component). Use the DC position or measuring both the ac component and the dc reference, and any time a very low frequency waveform (below 5 Hz) is to be observed. The GND position is required only when a zero-signal ground reference is required, such as for dc voltage readings.

4. Connect the ground clip of the probe to chassis ground of the equipment under test. Connect the tip of the probe to the point in the circuit where the waveform is to be measured.

WARNING

- a. If the equipment under test is a transformerless ac powered item, use an isolation transformer to prevent dangerous electrical shock.
 - b. The peak-to-peak voltage at the point of measurement should not exceed 600 volts when using the DIRect position of the probe.
5. Set the VOLTS/CM control 14 to a position that gives 2 cm to 6 cm (two to six large squares on the scale) vertical deflection.
The display on the screen will probably be unsynchronized. The remaining steps are concerned with adjusting synchronization and sweep speed, which presents a stable display showing the desired number of waveforms. Any signal that produces at least 1 cm vertical deflection develops sufficient trigger signal to synchronize the sweep.
 6. Set the SYNC switch 4 to the TVV position for observing television composite video waveforms synchronized with vertical blanking pulses, to the TVH position for observing television composite video waveforms synchronized with horizontal sync pulses, or the NOR position for all other waveforms.
 7. Set the TRIGGERING SOURCE switch 5 to the INT (internal) position when the waveform being observed is also to be used to trigger the sweep. Most waveforms should be viewed with this switch in the INT position. When an external sync source is required, use the EXT position.
 8. Set the TRIGGERING SLOPE switch 6 to (+) if the sweep is to be triggered by a positive going wave, and to (-) if the sweep is to be triggered by a negative going wave. For observing television composite video signals it is desired to sync the sweep to the horizontal line sync pulses or the vertical blanking pulses. Because the polarity of the composite video signals varies according to the point at which it is observed, use the following procedure:
 - a. If the observed sync pulses or blanking pulses are positive going (upward trace deflection is produced by a positive voltage), use the (-) position of the TRIGGERING SLOPE switch.
 - b. If the observed pulses are negative, use the (+) position of the TRIGGERING SLOPE switch.
 9. Set the SWEEP TIME/CM control 2 and VARIABLE/HOR GAIN control 3 for the desired number of waveforms. These controls may be set for viewing only a portion of a waveform,

but the trace becomes progressively dimmer as a proportionately smaller portion is displayed. This is because the writing speed increases but the sweep repetition rate does not change.

NOTE:

When using very fast sweep speed at low repetition rates, the operator may wish to operate with the intensity control toward maximum. Under these conditions, a retrace "pip" may appear at the extreme left of the trace. This does not in any way affect the oscilloscope operation and may be disregarded.

10. To synchronize the waveform, set the TRIG LEVEL control 8 fully counterclockwise to the AUTO position. Next turn the STABILITY control 7 counterclockwise until the trace disappears. Now turn the STABILITY control clockwise just past the point where the trace reappears. This should provide a stable waveform free of jitter. Do not turn the STABILITY control too far clockwise, as it will go into a free-running (non-synchronized) mode.
11. Step 10 assumes that you desire to use automatic sync, wherein the predominant point of the waveform is automatically selected as the sync trigger. If another point on the waveform is desired as the sync trigger (as is often the case in viewing sinusoidal waves), turn the TRIG LEVEL control 8 clockwise away from the AUTO position. Set the control by observing the waveform and note that it starts at the desired time. It may also be necessary to readjust the STABILITY control 7. This control has three general "modes" when rotated from one extreme to the other. On the counterclockwise end, no trace is produced, for the sync threshold level is set so none of the input signal is sufficient to trigger the sweep. At the clockwise extreme, the sync threshold is so low that anything will trigger the sweep, resulting in a free-running, unsynchronized mode. The center range provides the proper threshold for synchronization and results in the desired stable presentation. The boundaries of this center range depend upon the strength and type of signal input and the setting of the TRIG LEVEL control. However, the setting of the STABILITY control is not critical; it operates properly over this entire "center" area and the proper setting is easy to attain.
12. For a close-up view of a portion of the waveform, pull outward on the ◀▶ POS control 1. This expands the sweep by a factor of five (5X magnification) and displays only the center portion of the sweep. To view a portion to the left of center, turn the ◀▶ POS control 1 clockwise, and to view portions to the right of center, turn the control counterclockwise. Push inward on the control to return the sweep to the normal, non-magnified condition.

CALIBRATED VOLTAGE MEASUREMENT

(See Figure 4.)

Peak voltages, peak-to-peak voltages, dc voltages and voltages of a specific portion of a complex waveform are easily and accurately measured on this oscilloscope.

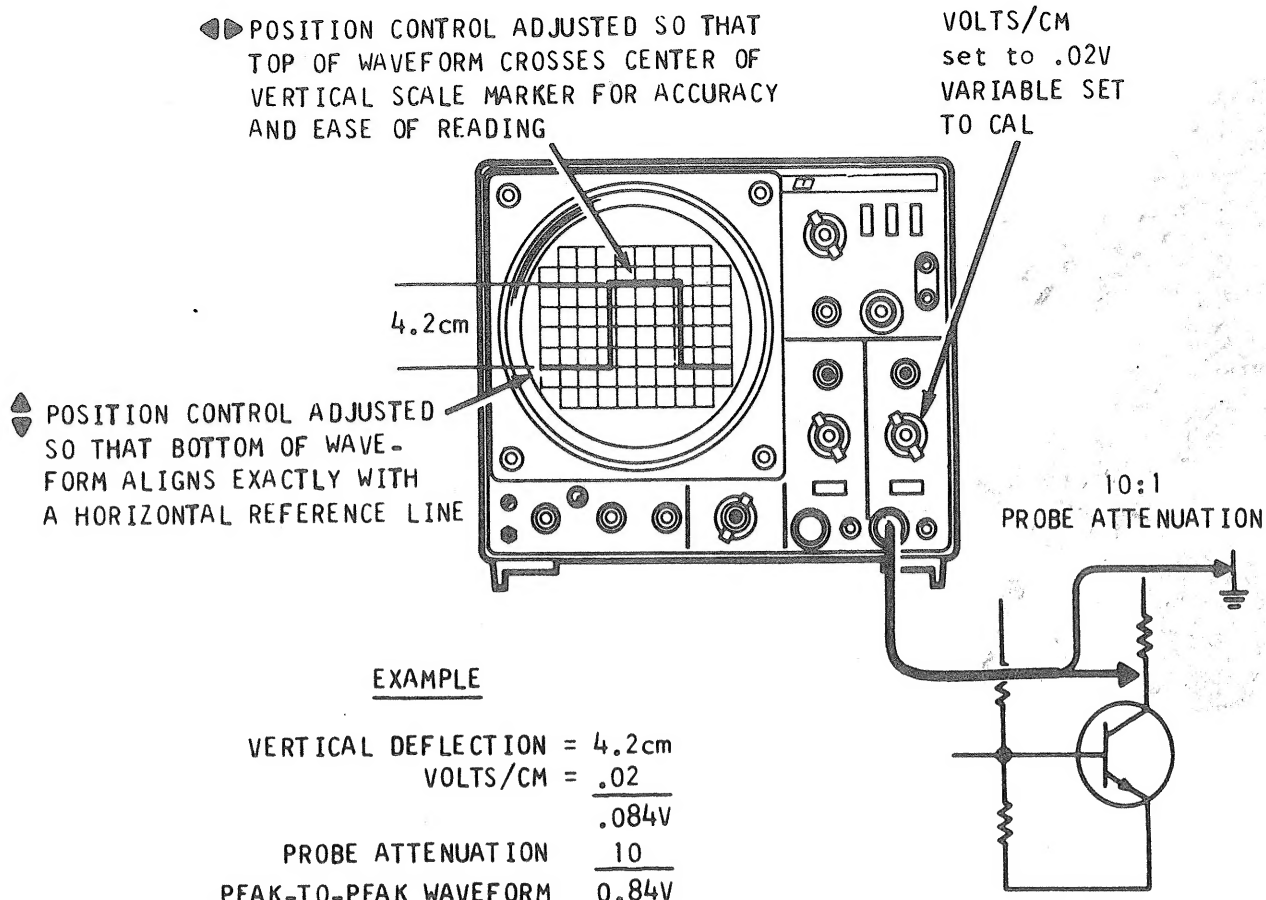


Figure 4 Typical Voltage Measurement

1. Adjust controls as previously instructed to display the waveform to be measured.
2. Be sure the vertical VARIABLE control 15 is set fully clockwise to the CAL position.
3. Set the VOLTS/CM control 14 for the largest vertical deflection possible without exceeding the limits of the vertical scale.
4. Read the amount of vertical deflection (in cm) from the scale. The POS control 12 may be readjusted to shift the reference point for easier scale reading if desired. When measuring a dc voltage, adjust POS control 12 to a convenient reference with the AC-GND-DC switch 18 in the GND position, then note the amount the trace is deflected when the switch is placed in the DC position. The trace deflects upward for a positive voltage input and downward for a negative voltage input.

NOTE:

For an accurate display of high-frequency waveforms above 5 MHz it is important that the probe be used in the 10:1 position to reduce circuit loading and that the oscilloscope controls be set so that the height of the pattern does not exceed 4 centimeters and that the trace be centered vertically.

5. Calculate the voltage reading as follows:
Multiply the vertical deflection (in cm) by the VOLTS/CM control 14 setting (see example in Figure 4). Don't forget that the voltage reading displayed on the oscilloscope is only 1/10th the

actual voltage being measured when the probe is set for 10:1 attenuation. The actual voltage is displayed when the probe is set for DIRECT measurement.

6. Calibration accuracy of this oscilloscope may be occasionally checked by observing the 1 volt peak-to-peak square wave signal available at the CAL 1Vpp jack 30. This calibrated source should read exactly 1 volt peak-to-peak. If a need for recalibration is indicated, see the "MAINTENANCE and CALIBRATION" section of the manual for complete procedures.

CALIBRATED TIME MEASUREMENT

(See Figure 5.)

Pulse width, waveform periods, circuit delays and all other waveform time durations are easily and accurately measured on this oscilloscope. Calibrated time measurements from 1 second down to .2 micro-second (μ S) are possible. At low sweep speeds, the entire waveform is not visible at one time. However, the bright spot can be seen moving from left to right across the screen which makes the beginning and ending points of the measurement easy to spot.

1. Adjust controls as previously described for a stable display of the desired waveform.
2. Be sure the VARIABLE/HOR GAIN control 3 is fully clockwise to the CAL position.
3. Set the SWEEP TIME/CM control 2 for the largest possible display of the waveform segment to be measured, usually one cycle.
4. If necessary, readjust the STABILITY and TRIG LEVEL controls 7 and 8 for the most stable

- display.
5. Read the amount of horizontal deflection (in cm) between the points of measurement. The \llcorner POS control 1 may be readjusted to align one of the measurement points with a vertical scale marker for easier reading.
 6. Calculate the time duration as follows:
Multiply the horizontal deflection (in cm) by the SWEEP TIME/CM control 2 setting (see example in Figure 5). Remember, when the 5X magnification is used, the result must be divided by 5 to obtain the actual time duration.
 7. Time measurements often require external sync. This is especially true when measuring delays. The sweep is started by a sync signal from one circuit and the waveform measured in a subsequent circuit. This allows measurement of the delay between the sync pulse and the subsequent waveform. To perform such measurements using external sync, use the following steps:
 - a. Set the TRIGGERING SOURCE switch 5 to the EXT position.
 - b. Connect a lead from the EXT SYNC/HOR jack 9 to the source of sync signal. Use a short shielded cable.

- c. Set the TRIGGERING SLOPE switch 6 to the proper polarity (+) or (—) for the sync signal.
- d. Readjust the STABILITY and TRIG LEVEL controls 7 and 8, if necessary, for a stable waveform.
- e. Set the SWEEP TIME/CM control 2 as for other time measurements. Do not set it to the EXT position. This position is for external horizontal deflection, not external sync.
- f. If measuring a delay, measure the time from the start of the sweep to the start of the waveform.

EXTERNAL HORIZONTAL INPUT

For some measurements, an external horizontal deflection signal is required. This may be a sinusoidal wave, such as used for phase measurement, or an external sweep voltage. This input voltage must be about 250 millivolts per cm of deflection (usually 2 volts or more peak-to-peak will provide satisfactory results). To use an external horizontal input, use the following procedure:

1. Set the SWEEP TIME/CM control 2 to the EXT position.
2. Connect the external horizontal signal source through a cable to the EXT SYNC/HOR jack 9.

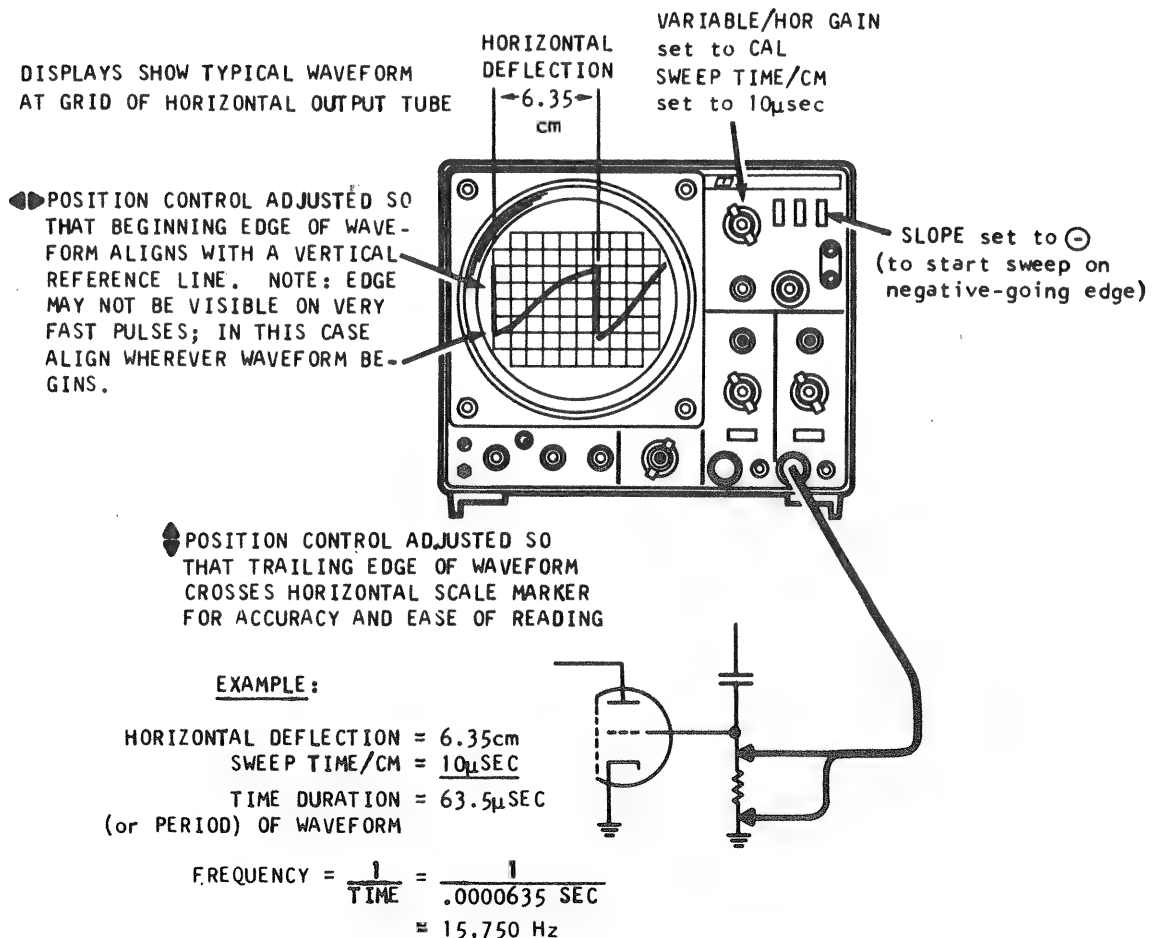


Figure 5. Typical Time Measurement

3. Adjust the amount of horizontal deflection with the VARIABLE/HOR GAIN control 3, which adjusts the gain of the horizontal amplifier.
4. All sync controls are disconnected and have no effect.

Z-AXIS INPUT

The trace displayed on the screen may be intensity modulated (Z-axis input) where frequency or time-scale markers are required. A 30-volt peak-to-peak or greater signal applied at the INT MOD (intensity modulation) jack 40 on the rear of the oscilloscope will provide alternate brightness and blanking of the trace. (See Figure 6.)

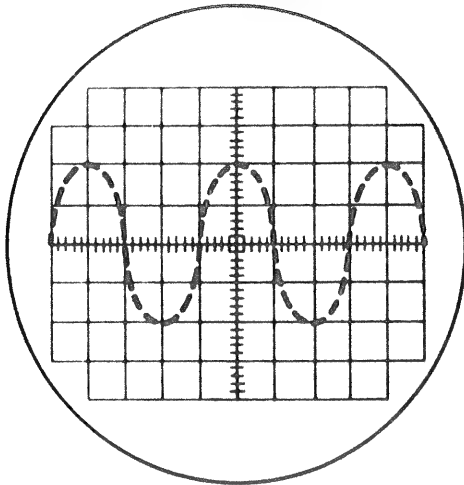


Figure 6. Oscilloscope Trace with Z-axis Input

DUAL TRACE OPERATION (Refer to Figure 1.)

Before outlining the operating procedures for dual trace operation, a brief description of the various operating modes of the oscilloscope will be described. In dual trace operation, signal inputs are applied to both the Channel 1 and Channel 2 Vertical input jacks. The type of display obtained depends on the position of the MODE switch 24.

CH 1. When the MODE switch is in the CH 1 position, only the Channel 1 input signal can be displayed on the oscilloscope screen, although two inputs may be applied to the oscilloscope.

CH 2. When the MODE switch is in the CH 2 position, only the input signal to Channel 2 will be displayed on the oscilloscope. The polarity of the Channel 2 waveform display can be reversed if desired by use of the CH 2 \blacksquare INV/ \blacksquare NOR switch 25.

CHOP. When it is desired to observe low frequency waveforms using sweep speeds of 2mS/CM or less, the CHOP mode of operation should be used. In this mode of operation a single trace is switched at a 140 KHz rate by an internally generated switching signal. When using the CHOP mode of operation, best results are obtained if external sync is used. At low sweep repetition rates, the switching frequency is sufficiently high to generate the illusion of two individual traces on the CRT screen. If there is no input to Channels 1 and 2, two horizontal lines will be present on the screen. These lines may be independently adjusted vertically by adjustment of the CH 1 \blacklozenge POS control 13, or

the CH 2 \blacklozenge POS control 12. If an input signal is applied to either or both vertical input jacks, the signal will be reproduced on each of the two oscilloscope traces. In this operating mode the polarity of the Channel 2 waveform display can be reversed by operation of the CH \blacksquare INV/ \blacksquare NOR switch 25. As the sweep repetition rate is increased to view higher frequency waveforms, the chopping signal will become visible in the oscilloscope display. The chopping effect becomes evident at sweep speeds in excess of .2mS/cm. At sweep speeds requiring higher sweep repetition rates, the ALT position of the MODE switch is selected to provide continuous waveform displays.

ALT. When this mode of operation is selected, the information supplied to Channels 1 and 2 is displayed on alternate sweeps. For example, one sweep will display Channel 1 information and upon completion of this sweep a second sweep displays the Channel 2 information. Again, the polarity of the Channel 2 waveform display can be reversed by operation of the CH 2 \blacksquare INV/ \blacksquare NOR switch 25. If the sweep repetition rate is sufficiently high (greater than 60 to 80 hertz) the illusion of simultaneous Channel 1 and Channel 2 displays occurs. At low sweep speeds and repetition rates, however, the alternate sweeping effect becomes noticeable. For example, if the oscilloscope is allowed to free run at sweep speeds of less than 20mS/CM, the effect is very noticeable. Because of this, the CHOP mode is employed for observation of low frequency waveforms using low sweep repetition rates.

ADD. In this operating mode, the Channel 1 and Channel 2 waveforms can be algebraically added, resulting in a single display which is the sum of the individual displays. Because the polarity of the Channel 2 signal can be reversed as previously described, it is, therefore, possible to obtain the sum or difference of the Channel 1 and Channel 2 waveform displays. This is a valuable tool in evaluating distortion, time delay and phase shift effects. It should be noted that in observing the difference of two sinusoidal waveforms, they must be frequency related and have a minimum of phase shift; otherwise the algebraic sum of two sinusoidal functions with a significant phase shift between them results in another sinusoidal waveform.

DUAL TRACE WAVEFORM OBSERVATION

(Refer to Figure 1.)

1. Turn off the Oscilloscope.
2. Connect the power cord to a 117 V, 60 hertz AC outlet.
3. Set the CH 1 \blacklozenge POS control 13, the CH 2 \blacklozenge POS control 12, and the \blacktriangleleft POS control 1 to the center of their ranges.
4. Set the TRIG LEVEL control 8 to the AUTO position (fully counterclockwise).
5. Set the CH 1 and CH 2 AC-GND-DC switches 22 and 18 to the GND position.
6. Set the MODE switch 24 to the CHOP or ALT position, depending upon the sweep speed and repetition rate which are to be used.

7. Turn on the oscilloscope by rotating the POWER/ILLUM control 29 clockwise. It will click on and the pilot lamp will light and graticule illumination will be maximum. Turn the control clockwise to the desired graticule illumination level.
8. After the cathode ray tube warms up, two traces should appear on the CRT screen.
9. If no traces appear, increase (clockwise rotation) the INTENSITY control 27 setting until the traces are easily observed. If the traces are still not visible, turn STABILITY control 7 fully clockwise which places the sweep generator in a free-running mode (no sync trigger required to produce sweep).
10. Adjust the FOCUS control 26 and INTENSITY control 27 for the thinnest, sharpest traces.
11. Readjust the position controls 1, 12, and 13, if necessary, to center the traces. The oscilloscope is now ready for making waveform measurements.

In observing simultaneous waveforms on Channels 1 and 2, it is necessary that the waveforms be related in frequency or that one of the waveforms be synchronized to the other although the basic frequencies may be different. An example of this is in checking a frequency divider or multiplier. The reference, or "Clock" frequency can be used on Channel 1, for example, and the multiple or sub-multiple of this reference frequency will be displayed on Channel 2. In this way, when the waveform display of Channel 1 is synchronized to the input waveform, the display on Channel 2 will also be in sync with the Channel 1 display. If two waveforms having no phase or frequency relationship to each other are displayed simultaneously, it will be difficult if not impossible to lock both waveforms in sync for any useful observation.

WAVEFORM OBSERVATION, DUAL TRACE OPERATION

After performing the initial starting procedure outlined above, the basic setup for observing two traces simultaneously is similar to that described under WAVEFORM OBSERVATION for single trace operation, the difference being that two traces are displayed rather than a single trace.

1. Perform the steps of the initial starting procedure then connect the probe cables to the CH 1 V INPUT and the CH 2 V INPUT receptacles, 23 and 20 respectively.
2. If the Model PR-16 or PR-20 oscilloscope probes are used, a 10:1 attenuation should be used except for waveform amplitudes of .5 V peak-to-peak or less. At the lower amplitude waveforms the DIR position should be used. See Figure 3 for changing the probe from 10:1 to DIR or vice versa. Wherever possible, the 10:1 position should be used to minimize circuit loading.
3. If it is desired to observe waveforms requiring sweep speeds of 2 mS/CM or less, the MODE switch 24 is placed in the CHOP position. In observing waveforms requiring higher sweep speeds, the MODE switch is placed in the ALT position.
4. Place the DC-GND-AC switches 23 and 20 for Channels 1 and 2, respectively, to the AC position. This is the position used for most measure-

ments and must be used if the point being measured includes a large dc component.

5. Connect the ground clips of the probes to the chassis ground of the equipment under test. Connect the tips of the probes to points in the circuit where the waveforms are to be measured. It is preferred that the signal to which the waveform will be synchronized be applied to the Channel 1 input.

WARNING

- a. If the equipment under test is a transformerless AC unit, use an isolation transformer to prevent dangerous electrical shock.
 - b. The peak-to-peak voltage at the point of measurement should not exceed 600 volts, if the probe is used in the DIR position.
6. Set the VOLTS/CM controls 13 and 12 for Channels 1 and 2 to a position that gives 2cm to 3cm vertical deflection. The displays on the screen will probably be unsynchronized. The remaining steps, although similar to those outlined for single trace operation, describe the procedure for obtaining stable, synchronized displays.
 7. Set the TRIGGERING SYNC switch 4 to the NOR position.
 8. Set the TRIGGERING SOURCE switch 5 to the CH 1 position if it is desired to synchronize the waveform displays with an externally applied trigger signal, the EXT position of the SOURCE switch is used. In addition, the triggering signal is applied to the EXT SYNC/HOR input jack 9.
 9. Set the TRIGGERING SLOPE switch 6 to the (+) position if the sweep is to be synchronized by a positive going portion of the waveform, or to the (-) position if the sweep is to be synchronized by a negative going portion of the input signal.
 10. Set the SWEEP TIME/CM control to the VARIABLE/HOR GAIN control 3 for the desired number of cycles of the waveforms displayed. The horizontal sweep adjustments apply for both Channel 1 and Channel 2 inputs. Adjustment of these controls affects the Channel 1 and Channel 2 waveform displays proportionately.
 11. Set the TRIG LEVEL control 8 fully counterclockwise to the AUTO position. Next turn the STABILITY control 7 counterclockwise until the traces disappear. Now turn the STABILITY control clockwise just past the point where the traces reappear. Turning the STABILITY control too far in a clockwise direction will cause the horizontal sweep to go into a free-running mode.
 12. If other than automatic sync operation is desired, as is often the case when viewing sinusoidal waveforms, turn the TRIG LEVEL control 8 clockwise away from the AUTO position. Set the control by observing the waveform and noting that it starts at the desired time. It may also be necessary to readjust the STABILITY control 7 over the center of its range of rotation to provide the required synchronization of the waveform display.
 13. The observed waveforms of Channels 1 and 2 can be expanded by a factor of 5 by pulling outward on the «» POS control 1. This control can then be rotated clockwise or counterclockwise

to view the left and right extremes of the waveform displays as desired. Push inward on the control to return the sweep to the normal, non-magnified condition.

Calibrated voltage measurements, calibrated time measurements and operation with external horizontal input as well as Z axis input are identical to those previously described for single trace operation. Either the Channel 1 or Channel 2 vertical adjustment controls can be used as required in conjunction with the horizontal sweep controls to obtain the required amplitude or time interval measurements. This can be done either by using the dual display facilities

such as the CHOP and ALT positions of the MODE switch or by reverting to single trace operation, using the CH 1 or CH 2 positions of the MODE switch.

14. The Channel 1 and Channel 2 waveform displays can be added algebraically by placing the MODE switch 24 in the ADD position. The CH 2 \square INV/ \square NOR switch 25 must be in the \square NOR position for algebraic addition of the waveform displays. By placing the CH 2 \square INV/ \square NOR switch in the \square INV position, the polarity of the Channel 2 waveform display is reversed and the difference of the Channel 1 and Channel 2 waveform displays is then obtained.

APPLICATIONS

DUAL TRACE OPERATION

The most obvious and yet the most useful property of the dual trace oscilloscope is that it affords the capability for viewing simultaneously two waveforms that are frequency or phase related or that have a common synchronizing voltage such as in digital circuitry. Simultaneous viewing of "Cause and Effect" waveforms is an invaluable aid to the circuit designer or the repairman. Several possible applications of the dual trace oscilloscope will be reviewed in detail to familiarize the user further in the basic operation of this oscilloscope.

FREQUENCY DIVIDER WAVEFORMS

Figure 7 illustrates the waveforms involved in a basic divide-by-two circuit. Figure A indicates the reference frequency or "Clock" pulse train. Figures B and C indicate the possible outputs of the divide-by-two circuitry. Figure 8 indicates the settings of specific oscilloscope controls for viewing these waveforms. In addition to these basic control settings, the TRIG LEVEL and the STABILITY controls as well as the Channel 1 and Channel 2 vertical adjustment controls should be set as required to produce suitable waveform displays. In the drawing of Figure 8 the waveform levels of 2cm are indicated.

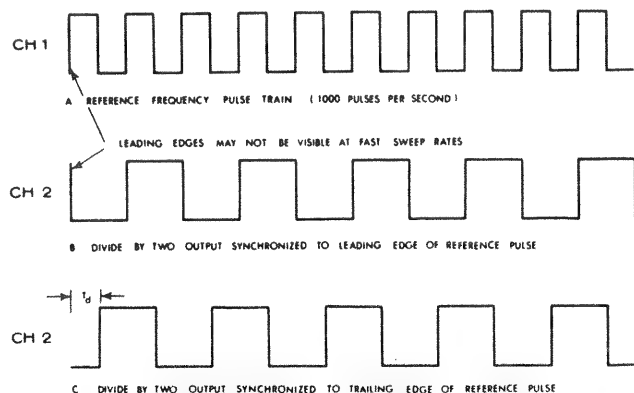


Figure 7. Waveforms in Divide-by-two Circuit

If the exact voltage amplitudes of the Channel 1 and Channel 2 waveforms are desired, the Channel 1 and Channel 2 VARIABLE controls must be placed in the CAL position. The Channel 2 waveform may be either that indicated in Figure 7B or 7C. In Figure 7C the divide by 2 output waveform is shown for the case where the output circuitry responds to a negative going waveform. In this case, the output wave-

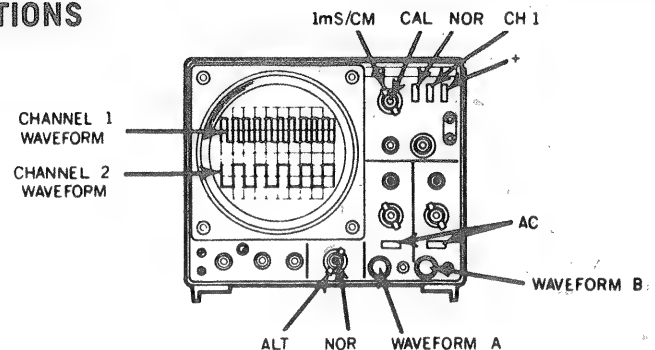


Figure 8. Oscilloscope Adjustments for Divide-by-two Circuit Checks

form is shifted with respect to the leading edge of the reference frequency pulse by a time interval corresponding to the pulse width.

DIVIDE-BY-8 CIRCUIT WAVEFORMS

Figure 9 indicates waveform relationships for a basic divide-by-eight circuit. The basic oscilloscope settings are identical to those used in Figure 8. The reference frequency of Figure 9A is supplied to the Channel 1 input, and the divide-by-eight output is applied to the Channel 2 input. Figure B indicates the ideal time relationship between the input pulses and the output pulse.

In an application where the logic circuitry is operating at or near its maximum design frequency, the accumulated rise time effects of the consecutive stages produce a built-in propagation delay which can be significant in a critical circuit and must be compensated for. Figure 9C indicates the possible time delay which may be introduced into a frequency divider circuit. By use of the dual trace oscilloscope the input and output waveforms can be superimposed to determine the exact amount of propagation delay which occurs.

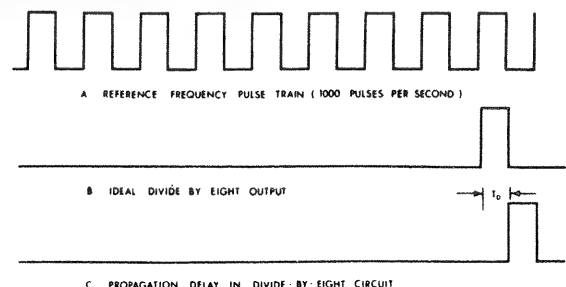


Figure 9. Waveforms in Divide-by-eight Circuit

GATED RINGING CIRCUIT

The circuit and waveforms of Figure 10 are shown to demonstrate the type of circuit in which the dual trace oscilloscope is effective both in design and troubleshooting applications. The basic oscilloscope control settings are identical to those of Figure 8. Waveform A is the reference waveform and is applied to Channel 1 input. All other waveforms are sampled at Channel 2 and compared to the reference waveform of Channel 1. The frequency burst signal can be examined more closely either by increasing the sweep time per centimeter to .5 mS per centimeter or by pulling out on the Δ POS control to obtain 5 times magnification. This control can then be rotated as desired to center the desired waveform information on the oscilloscope screen.

DELAY LINE TESTS

The dual trace feature of the oscilloscope can also be used to determine the delay times of transmission type delay lines as well as ultrasonic type delay lines. The input pulse can be used to trigger or synchronize the Channel 1 display and the delay line output can be observed on Channel 2. A repetitive type pulse will make it possible to synchronize the displays. The interval between repetitive pulses should be large compared to the delay time to be investigated. In addition to determining delay time, the pulse distortion inherent in the delay line can be determined by examination of the delayed pulse observed on the Channel 2 waveform display. Figure 11 demonstrates the typical oscilloscope settings as well as the basic test circuit. Typical input and output waveforms are shown on the oscilloscope display. Any pulse stretching and ripple can be observed and evaluated. The results of modifying the input and output terminations can be observed directly.

A common application of the delay line checks is found in color television receivers. Figure 12 shows the oscilloscope settings and typical circuit connections to check the "Y" delay line employed in the video amplifier section. The waveform and the output waveform using the horizontal sync pulse of the composite video signal for reference. The indicated delay is approximately one microsecond. In addition to determining the delay characteristics of the line, the output waveform reveals any distortion that may be introduced from an impedance mismatch or a greatly attenuated output resulting from an open line.

RELAY TESTING AND SEQUENCING

In certain relay applications the relay pull-in time as well as the drop-out time is critical or may be designed to some specific operating limits. For example, some relays used in time delay circuits have a designed drop-out time. In high powered transmitters relay sequencing is important. The antenna relay must open and close when no RF is present to avoid severe pitting which will reduce relay contact life considerably.

In evaluating performance of relays the operation is more of a transient type rather than a repetitive type. Usually, the transient resulting from energizing the relay coil is used as the trigger source. A voltage can be made available at the relay contacts to generate a transient when the contacts close.

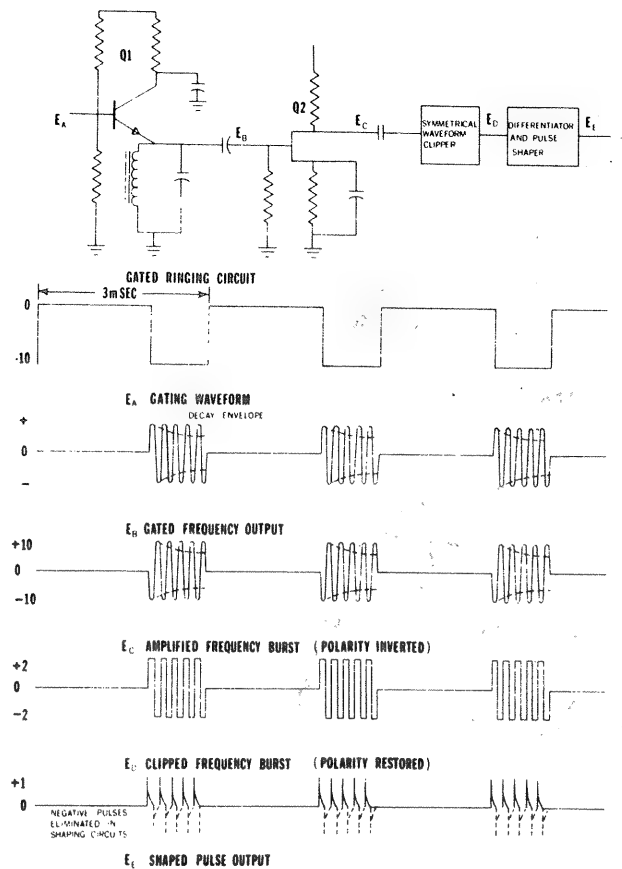


Figure 10. Gated Ringing Circuit and Waveforms

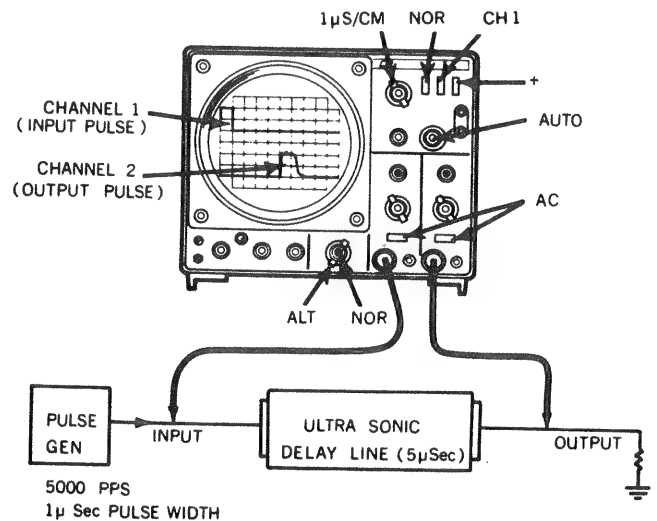


Figure 11. Delay Line Measurements

The interval between energizing the relay coil and the closing of the contacts is the pull-in time of the relay. The same applies when the relay coil is de-energized. The "break" transient of the relay coil serves as the sweep trigger and the opening of the relay contacts can be made to generate a transient. The interval between these two waveforms is the drop-out time of the relay.

Figure 13 indicates the relay arrangements in a medium or high power transmitter. The relay sequencing is such that the antenna relay opens and closes with no transmitter rf energy present. It should be noted that in evaluating this type of sequence that the CHOP position of the MODE

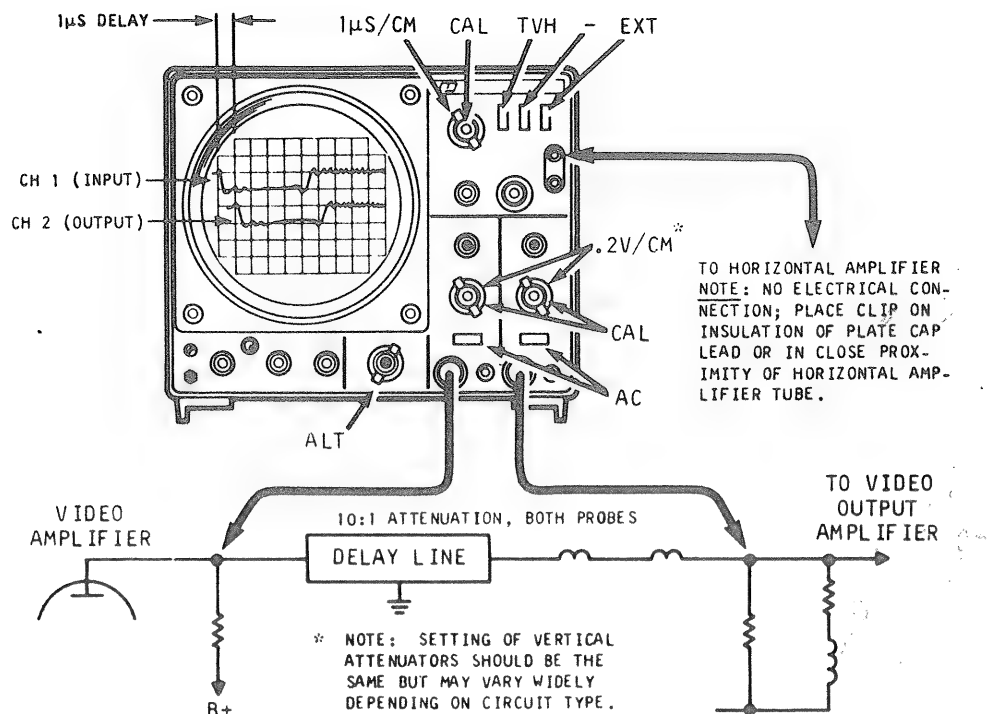


Figure 12. Checking the "Y" Delay Line in Color Television Receivers

switch 24 must be used. The reason is that the transient which triggers the sweep and the subsequent transients generated by relay closures must be observed on one sweep of the oscilloscope. This means that the Channel 1 and Channel 2 sweeps must be simultaneous. This is accomplished using the CHOP function. If the ALT position of the MODE switch were used, only the starting transient would be observed on the first sweep and the succeeding transients could be observed only if the push-to-talk switch were depressed once again. This means that the initial transient and the succeeding transients would not be viewed simultaneously. Also, to insure reliable triggering, the external trigger mode of operation should be used. Figure 13 shows a relay sequencing check performed using the dual trace oscilloscope. When the push-to-talk switch is closed to energize relay K1, the voltage at point A drops instantly from +12 volts to 0. This voltage is used as the external trigger and is applied to the EXT SYNC/HOR jack. This negative going transient provides the trigger to start the oscilloscope sweep. When the lower set of contacts of relay K1 are closed, the voltage at point B drops instantly from +12 volts to 0. This signal is coupled to the Channel 1V INPUT jack. When K2 is energized, the relay contacts close, causing the voltage at point C (relay K3) to drop instantly from +12 volts to 0. This signal is coupled to the Channel 2 V INPUT jack.

If the Channel 1 and Channel 2 DC-GND-AC switches are in the DC position, the Channel 1 and Channel 2 waveform displays will be observed to remain at +12 volts until relay contact closures cause the observed voltages to drop to 0. With the SWEEP TIME/CM switch in the 2 mS position and the VARIABLE/HOR GAIN control in the CAL position, the pull-in time for relay K1 is observed to be 4½ milliseconds. The time elapsed between the drop in voltage of waveform B and the drop in voltage of

waveform C is the pull-in time of relay K2. In this case it is approximately 4 milliseconds. When relay K2 pulls in, high voltage relay K3 is energized and shortly thereafter high voltage is applied to the high power stages of the transmitter. RF power is then developed at the transmitter output. Because of the relay sequencing, however, the transmit contacts of relay K2 have been closed and the transmitter power is applied directly to the antenna jack. If it is desired to determine when the transmitter power output is developed with respect to the closure of relay K2, a demodulator probe such as the B & K Model PR16 can be used to sample the RF power developed at the transmitter output. Figure 13B shows the desired power output build-up with respect to the closure of relay K2 (waveform B).

When the push-to-talk switch is released, K1 is de-energized and the voltage at point A returns to +12 volts. B+ is removed from the exciter and the capacitor discharge resistor causes the exciter voltage to drop to 0 almost instantly, thereby killing the drive to the transmitter output stages. This causes the transmitter power output to drop to zero. Relay K2 can be designed with a built-in drop-out delay to insure that the transmitter power output drops to zero before the K2 contacts open, disconnecting the transmitter from the antenna.

STEREO AMPLIFIER SERVICING

Another convenient use for dual channel Oscilloscopes is in troubleshooting stereo amplifiers. If identical channel amplifiers are used and the output of one is weak, distorted or otherwise abnormal, the dual trace oscilloscope can be efficiently used to localize the defective stage. With an identical signal applied to the inputs of both amplifiers, a side by side comparison of both units can be made by progressively sampling identical signal points in both amplifiers. When the defective or malfunctioning stage has been located, the effects of whatever

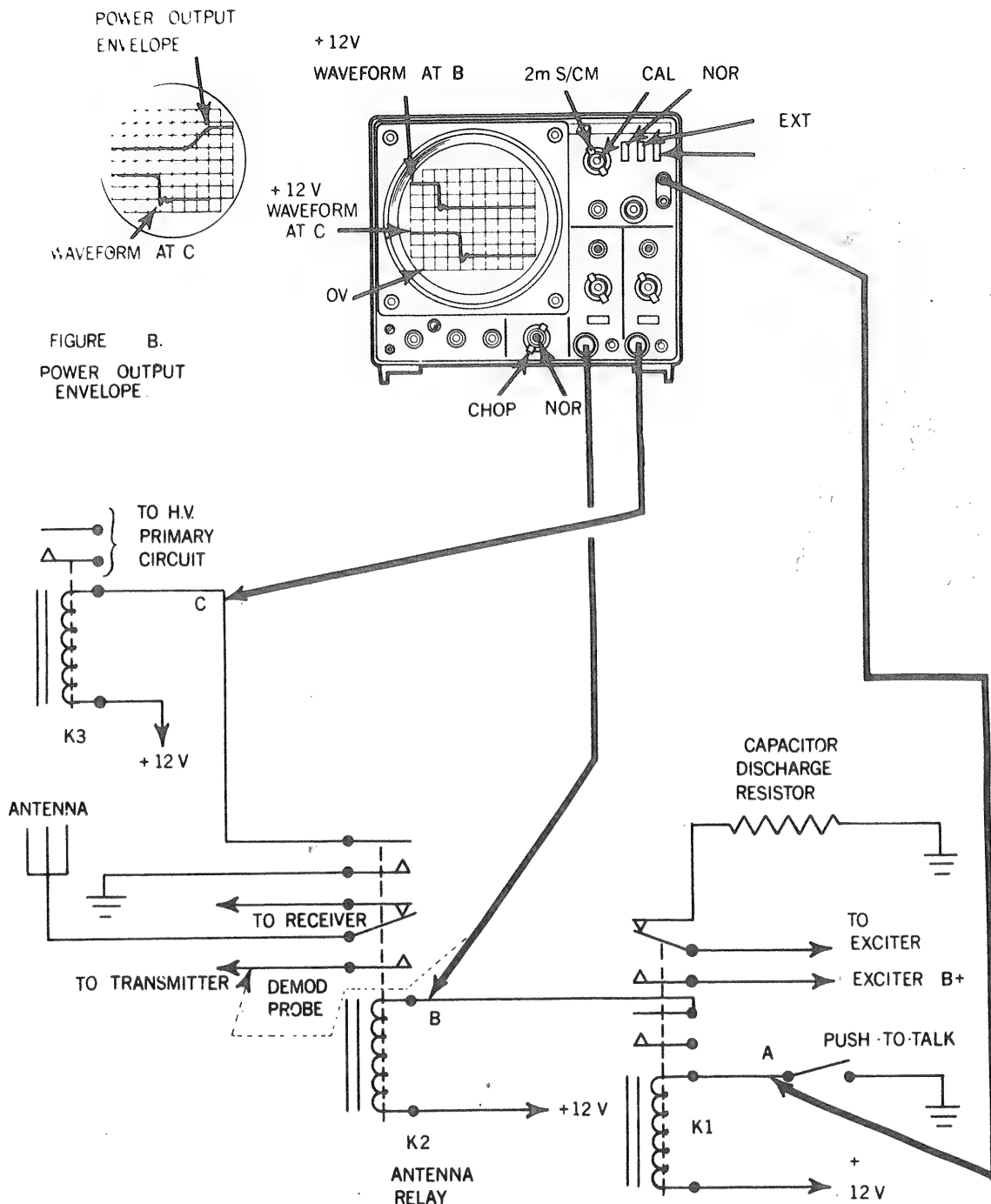


Figure 13. Transmitter Relay Sequencing

troubleshooting and repair methods are employed can be observed and analyzed immediately.

IMPROVING THE RATIO OF DESIRED TO UNDESIRE SIGNALS

In some applications, the desired signal may be riding on a large undesired signal component such as 60 hertz. It is possible to minimize or for practical purposes eliminate the undesired component. Figure 14 indicates the oscilloscope control settings for such an application. The waveform display of Channel 1 indicates the desired signal and the dotted line indicates the average amplitude variation corresponding to an undesired 60 hertz component. The Channel

2 display indicates a waveform of equal amplitude and identical phase to the average of the Channel 1 waveform. With the MOD switch in the ADD position, the CH 2 \blacksquare INV/ \blacksquare NOR switch is placed in the \blacksquare INV position. By adjusting the CH 2 vertical attenuator controls, the 60 hertz component of the Channel 1 signal can be cancelled by the Channel 2 input and the desired waveform can be observed without the 60 hertz component.

AMPLIFIER PHASE SHIFT MEASUREMENTS

In the single trace application section of this manual phase shift measurements using a single trace are described. In addition, in the square wave test-

ing section, square wave distortion is explained in terms of phase shift of the signal components which comprise the square wave. These phase shifts can be verified directly by providing a sine wave input signal to the amplifier and observing the phase of the output signal with respect to the input signal. If the signal frequencies being used are greater than 60 to 80 hertz, the ALT position of the MODE switch can be used to improve the waveform synchronization.

In all amplifiers, a phase shift is always associated with a change in amplitude response. For example, at the -3db response points, a phase shift of 45° occurs. Figure 15 illustrates a method of determining amplifier phase shift directly. In this particular case, the measurements are being made at approximately 5000 Hz. Whenever possible, the ALT position of the MODE switch should be used for improved waveform synchronization. The input signal to the audio amplifier is used as a reference and is applied to the CH 1 V INPUT jack.

The VARIABLE/HOR GAIN control is adjusted as required to provide a complete cycle of the input waveform displayed on 8 cm horizontally. A waveform height of 2 cm is used. The 8 cm display represents 360° at the displayed frequency and each centimeter represents 45° of the waveform. The

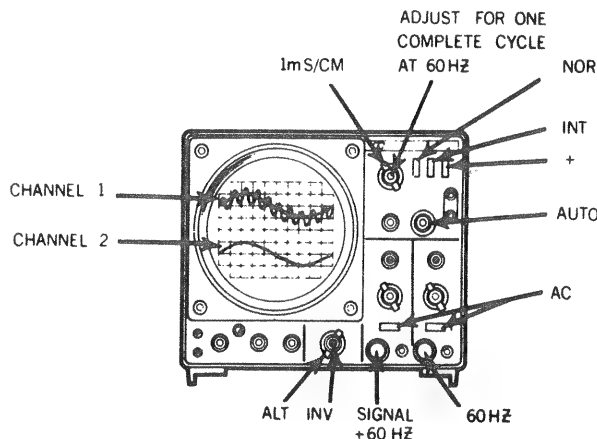


Figure 14. Improving Desired to Undesired Signal Ratio

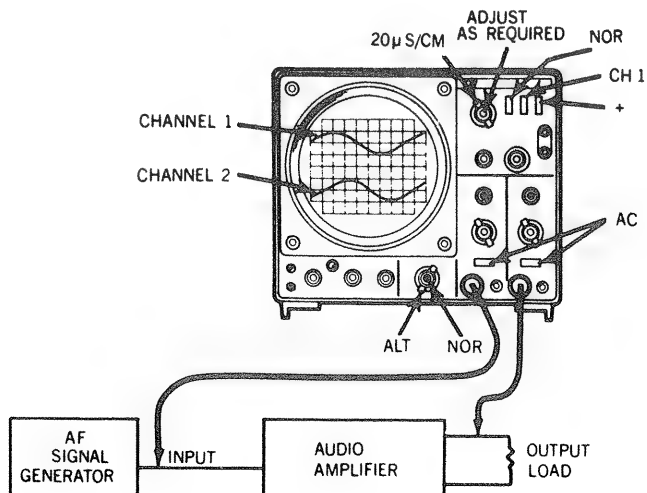


Figure 15. Measuring Amplifier Phase Shift

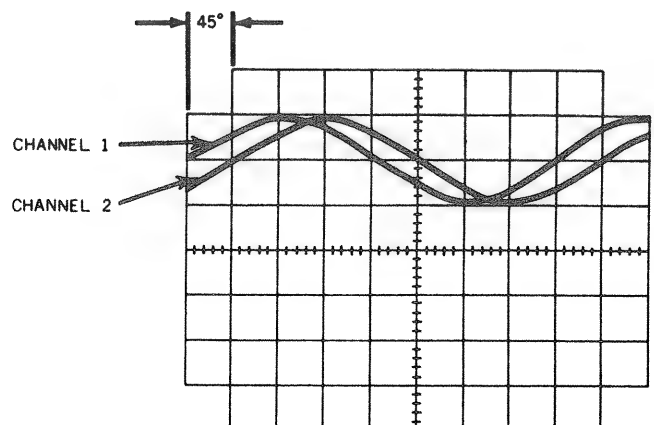
signal developed across the output of the audio amplifier is applied to the Channel 2 V INPUT jack. The vertical attenuator controls of Channel 2 are adjusted as required to produce a peak-to-peak waveform of 2 cm as shown in Figure 15.

The CH 2 POS control is then adjusted so that the Channel 2 waveform is displayed on the same horizontal axis as the Channel 1 waveform as shown in Figure 15B. The distance between corresponding points on the horizontal axis for the two waveforms then represents the phase shift between the two waveforms. In this case, the zero crossover points of the two waveforms are compared. It is shown that a difference of 1 centimeter exists. This is then interpreted as a phase shift of 45° .

TELEVISION SERVICING

Many of the television servicing procedures can be performed using single-trace operation. These are outlined later in the application section covering single-trace operation. One of these procedures, viewing the VITS (vertical interval test signal) can be done much more effectively using a dual trace oscilloscope. As outlined the single-trace applications section and as shown in Figures 22 and 23, the information on the field #1 and field #2 vertical blanking interval pulse is different. This is shown in detail in Figure 22. Also, because the oscilloscope sweep is synchronized to the vertical blanking interval waveform, the field #1 and field #2 waveforms are superimposed onto each other as shown in Figure 24A. With dual trace operation the signal information on each blanking pulse can be viewed separately without overlapping. Figure 16 indicates the oscilloscope control setting for viewing the alternate VITS.

1. The color television receiver on which the VITS information is to be viewed must be set to a station transmitting a color broadcast.
2. The control settings of Figure 16 are those required to obtain a 2-field vertical display on Channel 1.
3. With the oscilloscope and television receiver operating, connect the Channel 1 probe (Set at 10:1) to the video detector test point.
4. Set the TRIGGERING SLOPE switch as follows:
 - A. If the sync and blanking pulses of the observed video signal are positive, use the



- (—) switch position.
- B. If the sync and blanking pulses are negative, use the (+) switch position.
- Adjust the VARIABLE/HOR GAIN control so that 2 vertical fields are displayed on the oscilloscope screen.
 - Connect the Channel 2 probe (set to 10:1) to the video detector test point.
 - Set the MODE switch to the ALT position. Identical waveform displays should now be obtained on Channels 1 and 2.
 - Place the VARIABLE/HOR GAIN control in the CAL position.
 - Set the SWEEP TIME/CM control to the .1ms/CM position. This expands the display by increasing the sweep speed. The VITS information will appear toward the right hand portion of the expanded waveform displays. The waveform information on each trace may appear as shown in the drawing of Figure 23. Because there is no

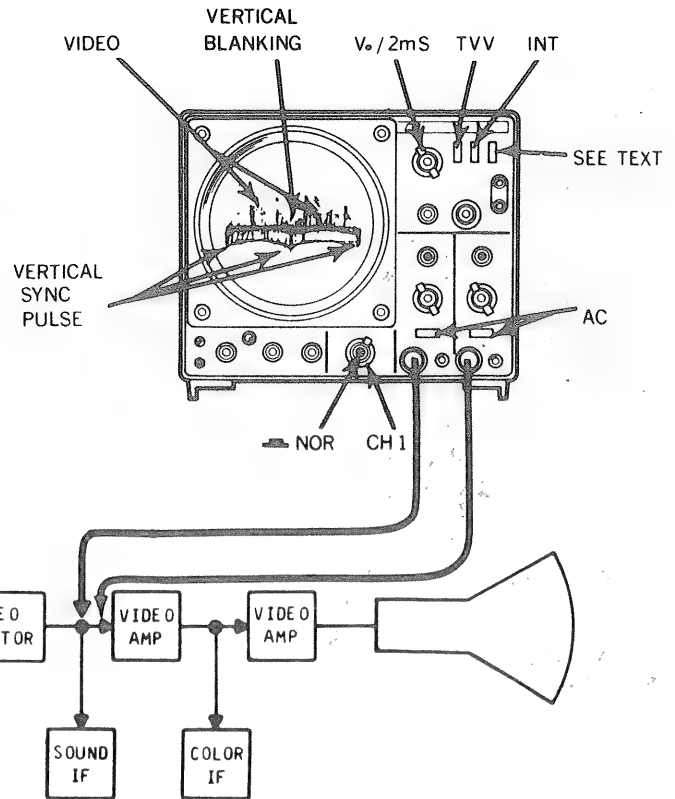


Figure 16. Viewing Field #1 and Field #2 VITS Information

that the sync signal is not interrupted. If the sync signal is interrupted, the waveform displays may reverse because, as previously explained, there is no provision in the oscilloscope to identify either of the two vertical fields which comprise a complete frame.

Figure 17 shows the dual-trace presentation of the field #1 and field #2 VITS information. The field #1 information is displayed on the trace.

SINGLE TRACE APPLICATIONS

In addition to the dual trace applications previously outlined, there are, of course, many service and laboratory applications where only single trace operation of the oscilloscope is required. After gaining experience with the oscilloscope, the user will be able to make the judgment as to whether a job can be performed more efficiently by using the single trace or the dual trace method of operation. The following are applications in which single trace operation is adequate. In several cases, it will be found that an alternate method using the dual trace application has been described for the same application. For all of the following applications the most flexible operation will be obtained if the Channel 2 vertical amplifier is used with the MODE switch in the CH 2 position. This arrangement provides complete triggered sweep as well as free running operation of the oscilloscope, and, in addition, by operation of the CH 2 \square INV/ \square NOR switch, whatever waveform is obtained can be inverted in polarity if desired by the operator.

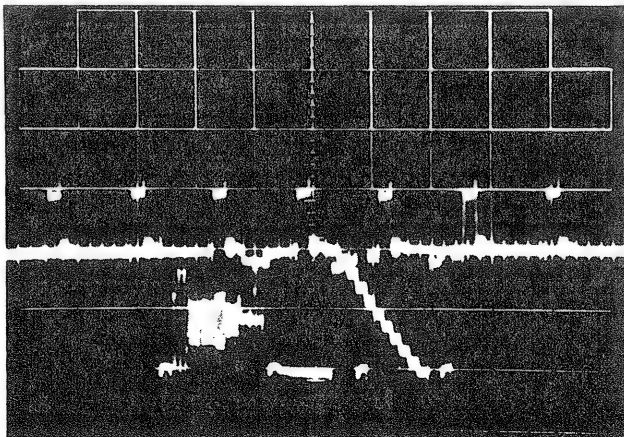


Figure 17. Oscilloscope Presentation of Field #1 and Field #2 VITS Information.

APPLICATIONS

TELEVISION SERVICING

A triggered sweep oscilloscope is advantageous in servicing and aligning television receivers. This oscilloscope also includes several features that were incorporated to make television servicing easier and more comprehensive. These features include:

- Sync separator and selection of TVV (vertical) or TVH (horizontal) sync to trigger the sweep for observing vertically or horizontally synchronized video.
- Sweep speed automatically set to display two horizontal lines or two vertical frames of video in the TVH and TVV positions of the SWEEP TIME/CM control.
- Vector overlay for color demodulator checks.
- Wide bandwidth for high resolution video and pulse presentation.
- High impedance (10 megohm), low capacitance (18pF) probe (in 10:1 position) does not appreciably load circuit, shift frequency, or distort waveforms.

SIGNAL TRACING AND PEAK-TO-PEAK VOLTAGE READINGS

For general troubleshooting and isolation of troubles in television receivers (or almost any other electronic equipment for that matter), the oscilloscope is an indispensable instrument. It provides a visual display of absence or presence of normal signals. This method (signal tracing) may be used to trace a signal by measuring several points in the signal path. As measurements proceed along the signal path, a point may be found where the signal disappears. When this happens, the source of trouble has been located.

However, the oscilloscope shows much more than the mere presence or absence of signal. It provides a peak-to-peak voltage measurement of the signal. The cause of poor performance can often be located by making such peak-to-peak voltage measurements. The schematic diagram or accompanying service data on the equipment being serviced usually includes waveform pictures. These waveform pictures include the required sweep time and the normal peak-to-peak voltage. Compare the peak-to-peak voltage readings on the oscilloscope with those shown on the waveform pictures. Any abnormal reading should be followed by additional readings in the suspected circuits until the trouble is isolated to as small an area as possible. The procedures for making peak-to-peak voltage measurements are given earlier in the CALIBRATED VOLTAGE MEASUREMENT paragraph.

COMPOSITE VIDEO WAVEFORM ANALYSIS

Probably the most important waveform in television servicing is the composite waveform consisting of the video signal, the blanking pedestals

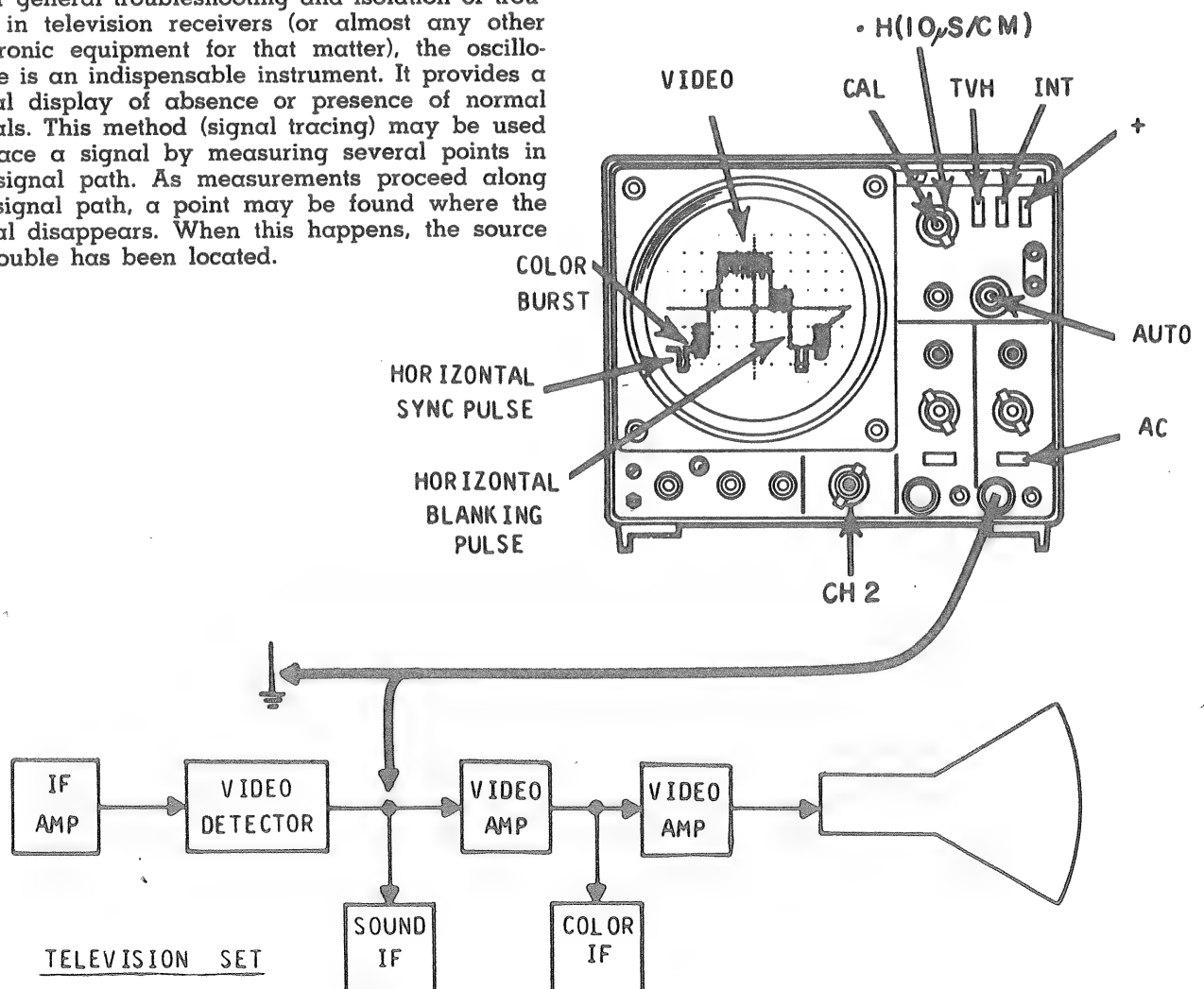


Figure 18. Horizontal Lines of Composite Video Signal

and the sync pulses. Figures 18 and 19 show typical oscilloscope traces when observing composite video signals synchronized with horizontal sync pulses and vertical blanking pulses. Composite video signals can be observed at various circuits of the television receiver to determine whether circuits are performing normally. Knowledge of waveform makeup, the appearance of a normal waveform, and the causes of various abnormal waveforms help the technician locate and correct many problems. The technician should study such waveforms in a television receiver known to be in good operating condition, noting the waveform at various points in the video amplifier.

To set up the oscilloscope for viewing television composite video waveforms, use the following procedure:

1. Tune the television set to a local channel.
2. Set the SYNC switch to TVH for horizontal pulse sync or TVV for vertical pulse sync. Also set the SWEEP TIME/CM control to TVH for horizontal line viewing or to TVV for vertical frame viewing.
3. Set the TRIGGERING SOURCE switch to INT.
4. With the TRIG LEVEL control initially set to AUTO, adjust the INTENSITY for a trace.
5. Set the AC-GND-DC switch to AC and connect the probe to the V INPUT jack. Connect the ground clip of the probe to the television set chassis. With the probe set at 10:1, connect the tip of the probe to the video detector output.
6. Set the VOLTS/CM control for largest vertical deflection without going off scale.
7. Set the TRIGGERING SLOPE switch as follows:
 - a. If the sync and blanking pulses of the observed video signal are positive, use the (—) switch position
 - b. If the sync and blanking pulses are negative, use the (+) switch position.
8. Turn the STABILITY control counterclockwise until no sweep appears. Finally, increase the STABILITY setting (clockwise) until the sweep reappears. This should provide a very stable waveform presentation.

9. Adjust INTENSITY and FOCUS for desired brightness and best focus.
10. To view a specific position of the waveform, such as the color burst, pull outward on the «» POSITION control for 5 x magnification. Rotate the same control left or right to select the desired portion of the waveform to be viewed.
11. Composite video waveforms may be checked at other points on the video circuits by moving the probe tip to those points and changing the VOLTS/CM control setting as required to keep the display within the limits of the scale, and by readjusting the STABILITY control to maintain stabilization. The polarity of the observed waveform may be reversed when moving from one monitoring point to another; therefore, it is important to remember that best synchronization of the observed waveform is obtained if the TRIGGERING SLOPE switch is used as outlined in preceding Paragraph 7.

SYNC PULSE ANALYSIS

The i-f amplifier response of a television receiver can be evaluated to some extent by careful observation of the horizontal sync pulse waveform. The appearance of the sync pulse waveform is affected by the i-f amplifier bandpass characteristics. Some typical waveform symptoms and their relation to i-f amplifier response are indicated in Figure 20. Sync pulse waveform distortions produced by positive or negative limiting in i-f overload conditions are shown in Figure 21.

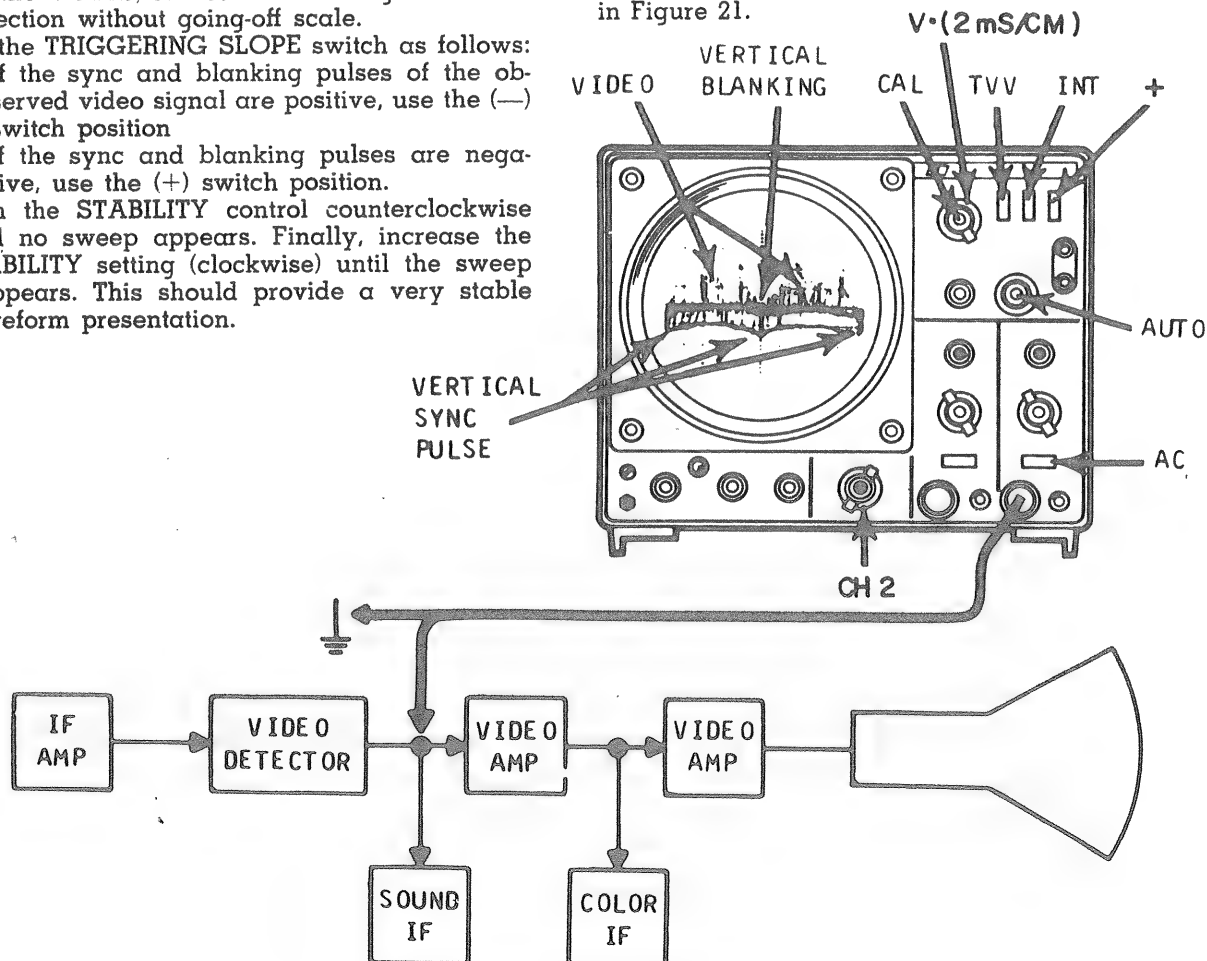


Figure 19. Vertical Fields of Composite Video Signal

| CIRCUIT DEFECT | HORIZONTAL PULSE DISTORTION | OVERALL RECEIVER FREQUENCY RESPONSE | EFFECT ON PICTURE |
|---|-----------------------------|-------------------------------------|--|
| NORMAL CIRCUIT | | | PICTURE NORMAL |
| LOSS OF HIGH FREQUENCY RESPONSE | | | LOSS OF PICTURE DETAIL |
| EXCESSIVE HIGH FREQUENCY RESPONSE, NON-LINEAR PHASE SHIFT | | | FINE VERTICAL BLACK & WHITE STRIATIONS FOLLOWING A SHARP CHANGE IN PICTURE SHADING |
| LOSS OF LOW FREQUENCY RESPONSE | | | CHANGE IN SHADING OF LARGE PICTURE AREAS; SHEARED PICTURE |

Figure 20. Analysis of Sync Pulse Distortion

VITS (VERTICAL INTERVAL TEST SIGNAL)

Most network television signals contain a built-in test signal (the VITS) that can be a very valuable tool in troubleshooting and servicing television sets. This VITS can localize trouble to the antenna, tuner, i-f or video sections and shows when realignment may be required. The following procedures show how to analyze and interpret oscilloscope displays of the VITS.

The VITS is transmitted during the vertical blanking interval. On the television set, it can be seen as a bright white line above the top of the picture, when the vertical linearity or height is adjusted to view the vertical blanking interval (on TV sets with internal retrace blanking circuits, the blanking circuit must be disabled to see the VITS).

The transmitted VITS is a precision sequence of specific frequency, amplitude, and waveshape as shown in Figures 22 and 23. The television networks use the precision signals for adjustment and checking of network transmission equipment, but the technician can use them to evaluate television set performance. The first frame of the VITS (line 17) begins with a "flag" of white video, followed by sine wave frequencies of 0.5 MHz, 1.5 MHz, 2 MHz, 3 MHz,

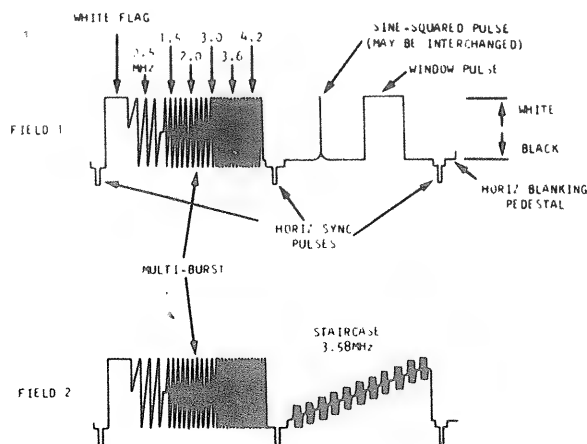
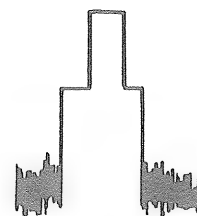
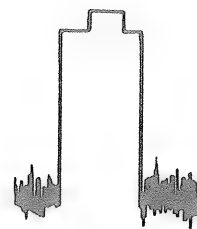


Figure 22. VITS Signal, Field 1 and Field 2

NORMAL
SYNC PULSE



SYNC PULSE
COMPRESSION
CAUSED BY
LIMITING



'WHITE'
SAURATION
CAUSED BY
LIMITING

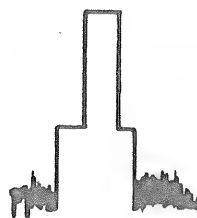


Figure 21. Sync Pulse Waveforms

3.6 MHz, (3.58 MHz), and 4.2 MHz. This sequence of frequencies is called the "multi-burst". The first frame of field #2 (line 279) also contains an identical multi-burst. This multi-burst portion of the VITS is the portion that can be most valuable to the technician. The second frame of the VITS (lines 18 and 280), which contains the sine-squared pulse, window pulse and the staircase of 3.58 MHz bursts at progressively lighter shading, are valuable to the network, but have less value to the technician. As seen on the television screen, field #1 is interlaced with field #2 so that line 17 is followed by line 279 and line 18 is followed by line 280. The entire VITS appears at the bottom of the vertical blanking pulse and just before the first line of video.

Each of the multi-burst frequencies is transmitted at equal strength. By observing the comparative strengths of these frequencies after the signal is processed through the television receiver, the frequency response of the set is checked.

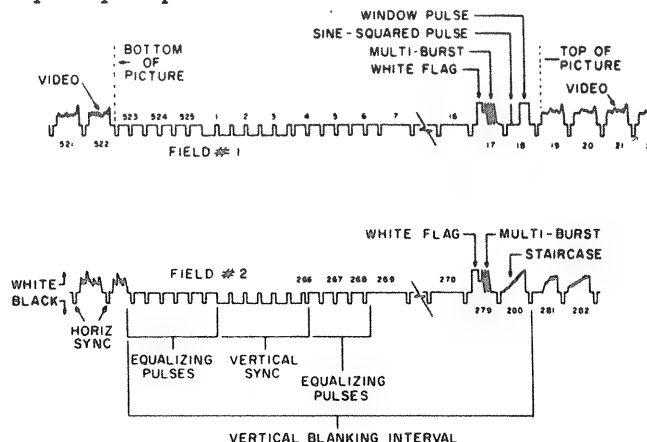


Figure 23. Vertical Blanking Interval Showing VITS Information

Set up the oscilloscope as follows to view the VITS:

1. Connect the CH 2 probe (set at 10:1) to the output of the video detector or other desired test point in the video section of the television set.
2. If the television set has a vertical retrace blanking circuit, bypass this circuit during the measurement.
3. Set the MODE switch to CH 2.
4. Set up the oscilloscope for TVV sync and TVV sweep time as previously described. Two vertical frames will be visible.
5. Place the VARIABLE/HOR. GAIN control in the CAL position.
6. Reduce sweep time to .1 millisecond per centimeter (.1 ms/CM) with the SWEEP TIME/CM switch. This expands the display by increasing the sweep speed. The VITS information will appear to the right on the expanded waveform display.
7. Further expand the sweep with the 5X magnification (pull outward on the \blacktriangleleft POS control). Rotate the \blacktriangleleft POS control in a counterclockwise direction, moving the trace to the left, until the expanded VITS appears.

NOTE: The brightness level of the signal display will be reduced because, although the repetition rate is only 60 Hz ($\approx 16,000 \mu\text{sec. period}$), the writing speed is $20 \mu\text{sec/cm}$ (.1 ms/cm magnified five times).

8. The waveform should be similar to that shown in Figure 24. For the oscilloscope display, each vertical sync pulse starts a new sweep. This causes line 17 and line 279 (multi-burst) to be superimposed, as are lines 18 and 280. The multi-burst signals are identical which reinforces the trace. However, lines 18 and 280 are not identical and both signals are superimposed over each other.
9. The presentation of the preceding paragraphs (Figure 24) is the limit of observation possible with a single-trace oscilloscope. With this oscilloscope, however, a single field VITS presentation can be obtained by placing the MODE switch in the ALT. position. This causes the Channel 2 information to be displayed on alternate sweeps, as are the Field #1 and Field #2 VITS. Because there is no provision for pre-selecting the Field #1 or Field #2 information, either Field #1 or Field #2 (Figure 23) will appear. The multi-burst information in the VITS is the most valuable for troubleshooting television receivers and, because it is present on both Field #1 and Field #2 VITS, either can be used for troubleshooting and signal tracing.

Now to analyze the waveform. All frequencies of the multi-burst are transmitted at the same level, but should not be equally coupled through the receiver due to its response curve. Figure 25 shows the desired response for a good color television receiver, identifying each frequency of the multi-burst and showing the allowable amount of attenuation for each. Remember that -6 dB equals half the reference voltage (the 2.0 MHz modulation should be used for reference).

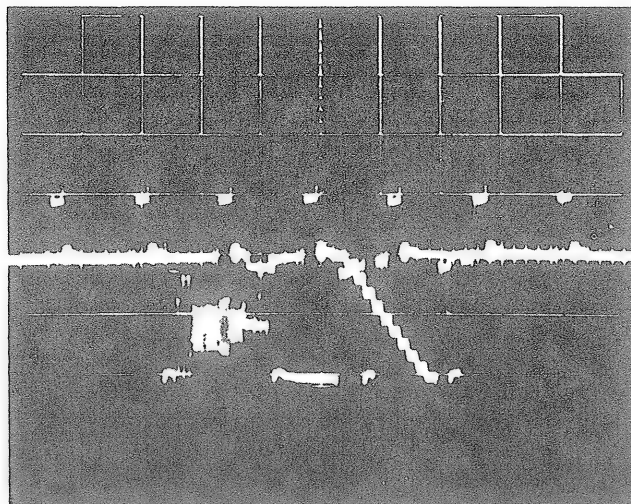


Figure 24. VITS as Seen on Oscilloscope, Single-Trace Operation

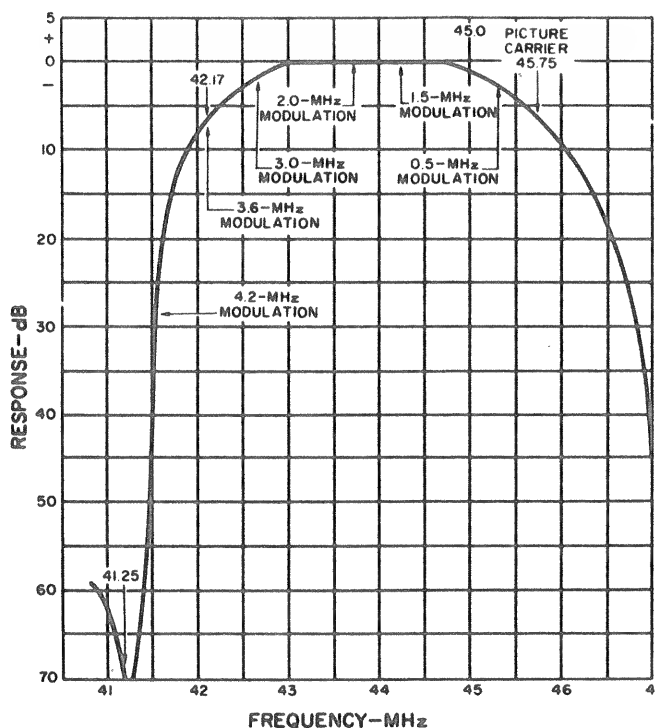


Figure 25. Color TV I-F Amplifier Response Curve

To localize trouble, start by observing the VITS at the video detector. This will localize trouble to a point either before or after the detector. If the multi-burst is normal at the detector, check the VITS on other channels. If some channels look okay but others do not, you probably have tuner or antenna-system troubles. Don't overlook the chance of the antenna system causing "holes" or tilted response on some channels. If the VITS is abnormal at the video detector on all channels, the trouble is probably in the i-f amplifier stages.

As another example, let us assume that we have a set on the bench with a very poor picture. Our oscilloscope shows the VITS at the video detector to be about normal except that the burst at 2.0 MHz is low compared to the bursts on either side. This suggests an i-f trap is detuned into the passband,

chopping out frequencies about 2 MHz below the picture carrier frequency. Switch to another channel carrying VITS. If the same thing is seen, then our reasoning is right, and the i-f amplifier requires realignment. If the poor response at 2 MHz is not seen on other channels, maybe an FM trap at the tuner input is misadjusted, causing a bite on only one channel. Other traps at the input of the set could similarly be misadjusted or faulty.

If the VITS response at the detector output is normal for all channels, the trouble will be in the video amplifier. Look for open peaking coils, off-value resistors, solder bridges across foil patterns, etc.

VECTORSCOPE OPERATION

Performance testing and adjustment of the color circuits in color television receivers is simplified by using the vectorscope operation of the oscilloscope. The additional equipment needed is a color bar generator. The B & K color bar generators are ideally suited.

First the horizontal and vertical gain of the oscilloscope must be equalized (See Figure 26).

1. Remove the linear scale and replace it with the vector overlay (Simply remove the four bezel retaining nuts and lift off the bezel and linear scale as in Figure 55).

2. Connect the color bar generator to the television set and tune in the color bar pattern.
3. Adjust the television set's hue and brilliance controls to mid-range.
4. Set the SWEEP TIME/CM control to the EXT position.
5. Connect the probe cable to the CH 2 V INPUT receptacle and another coaxial or shielded test lead to the EXT SYNC/HOR jack. Connect both probes to the driven element of the red gun, usually the grid. If the cathode is the driven element, then connect to the cathode. (The driven element is the element to which the output signal of the color amplifier is applied.)
6. Adjust the vertical and horizontal gain controls to obtain a compressed 45° pattern that approximately fills the vector overlay. The oscilloscope is now set up for vectorscope operation.
7. For vectorscope presentation, merely move the horizontal probe to the driven element of the blue gun. The color vector pattern is the same type as given by the television set manufacturer. Figure 27 shows typical displays obtained for sets using 105 degree systems and 90 degree systems with either grid drive or cathode drive.

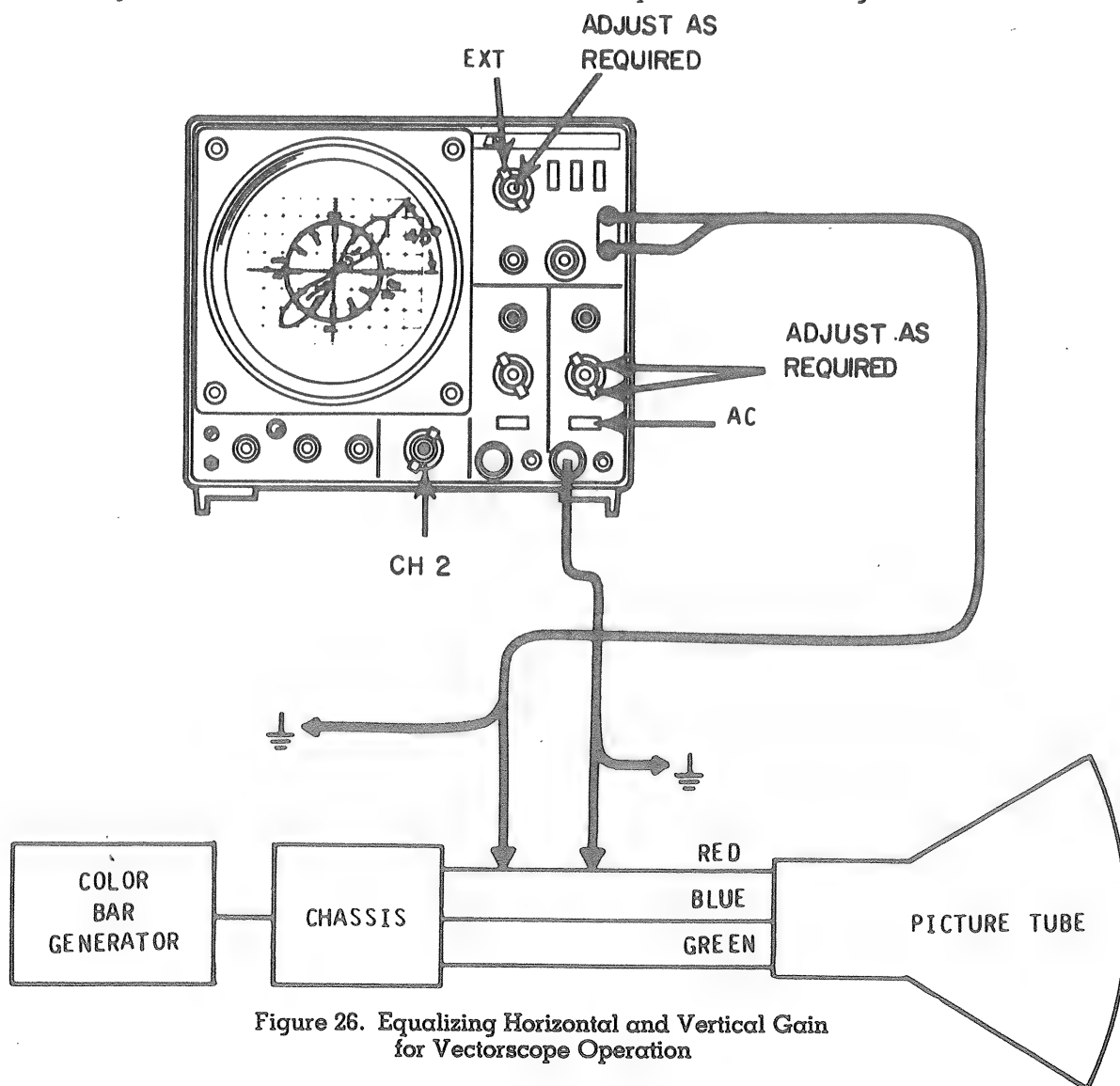


Figure 26. Equalizing Horizontal and Vertical Gain for Vectorscope Operation

NOTE: If the picture tube uses cathode drive, the burst will appear on the right side of the screen. Just rotate the vector overlay 180° so the BURST label is on the right side. The color bars will then align with the vector overlay.

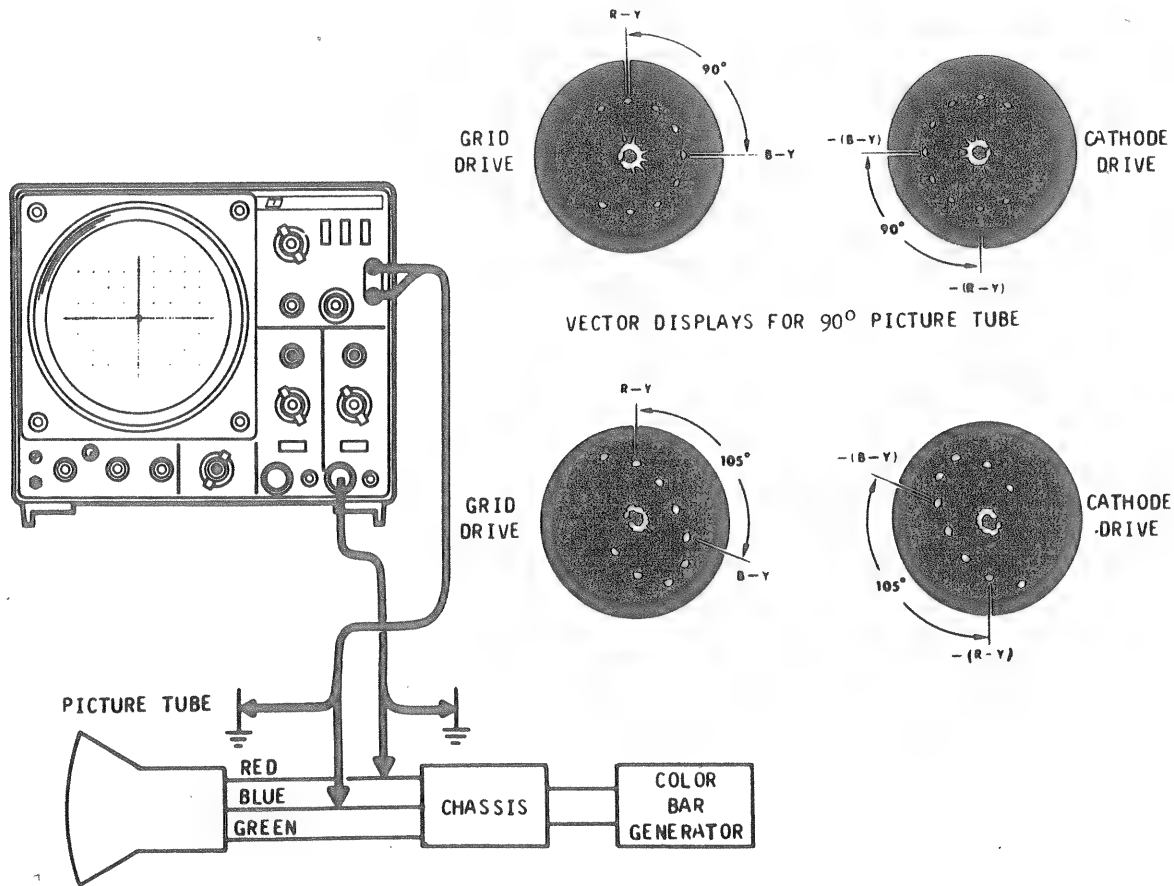
The vector display provides a very quick measurement of the functions of the demodulators in a color TV set. The serviceman should familiarize himself with the effect on the pattern produced by the color controls. He should observe that the color amplitude control will vary the size of the petals but not their position. The hue control changes the position of the petals but not their amplitude. Lastly, 105° sets will have a more elliptical pattern than 90° sets. The table below lists some common troubles and their effect on the pattern.

The vector display can be used to check the

range of the color sets hue control. It should be possible to rotate the R-Y petal about the vertical axis. At the center of the hue control the R-Y petal should be vertical. If it is not, locate the CHROMA reference oscillator. In most sets this oscillator is transformer coupled to the demodulators.

A slight touch up of this transformer is all that is necessary to bring the R-Y petal to a vertical position. Do not attempt to make any adjustments on the chroma bandpass amplifiers. This amplifier is aligned by a sweep generator and cannot in general be aligned by just a vector display.

If the set has adjustable demodulators, the vector display can also be used for demodulator alignment. Follow the manufacturer's alignment procedure to locate the proper coils and instead of counting bars simply adjust for the correct angle between R-Y and B-Y.



| TROUBLE | EFFECT ON PATTERN | EFFECT ON T.V. |
|--------------------------------------|--|--------------------------------------|
| Loss of color sync. | Petals of pattern will rotate | Varying Colors |
| Overloading of color amplifiers | Petals are crushed or flattened | Color Distortion |
| Color amplifiers unbalanced or weak. | Flower pattern very elliptical | Color Distortion |
| Lack of Range of Hue Control | R-Y petal cannot be made to be vertical. | Hue control won't adjust flesh-tones |
| Demodulator out of Alignment | Angle between R-Y petal and B-Y petal not to manufacturer's specification (90° or 105° General Specification). | Wrong colors |

Figure 27. Vectorscope Operation and Patterns

TELEVISION ALIGNMENT

INTRODUCTION

Alignment of tuners, the video i-f strip, and chroma circuits in television receivers requires a high quality oscilloscope, such as this instrument. The additional pieces of test equipment required are sweep generators for video sweep, i-f sweep and r-f sweep, marker generators, dc bias supplies and a VTVM. The sweep generator method of alignment displays a bandpass response curve on the screen of the oscilloscope of the type always shown in theory books and in the television set manufacturer's alignment instructions (typical response curves are shown in Figure 28).

The ideal instruments for television alignment are this oscilloscope and the B & K Sweep/Marker Generator. The B & K Sweep/Marker Generator provides all necessary sweep ranges, markers and dc bias voltages, all from one instrument. The simplified operating procedure and calibrated accuracy of the instrument results in precision alignment.

For complete alignment instructions of each particular television set, follow the manufacturer's instructions. However, the following general set-up instructions demonstrates use of the oscilloscope for sweep-frequency alignment.

In this manual, only the proper use of the oscilloscope in television is emphasized. Proper use of the sweep generator and other equipment required for alignment should be provided in the instruction manuals for those instruments.

NOTE: For a comprehensive analysis of television alignment, we recommend the instruction manual for the B & K Model 415 Sweep/Marker Generator. This "handbook of television alignment" includes not only the procedures for using the instrument, but all the how and why answers about television alignment in general. Even if you use other sweep generators, this book provides valuable procedures, insights and tips that will make alignment easier and more professional. The many illustrations and easy-to-understand step-by-step approach qualify it as the "how to align" textbook. Copies are available from your B & K distributor or factory.

IMPORTANCE OF SWEEP ALIGNMENT

The most rapid way to determine the overall condition of the tuner, i-f and chroma portions of the television receiver is to provide a constant-amplitude signal which sweeps through the entire bandwidth of a given television channel at a controlled, repetitive rate. As this signal is processed through the tuned portions of the receiver, it is shaped by the gain and bandpass properties of the various sections. Because the signal is channeled from one series of tuned circuits to another it is important that each section has the proper characteristics. If the signal is demodulated at certain points and the envelope observed, the gain and bandwidth properties up to that point can be determined.

Figure 28 shows the sweep signal with basic response curves of the tuner, i-f amplifiers and chroma bandpass circuits below it. The bandwidths shown are approximately to scale. These outlines are similar to the curves that would be obtained if the outputs of the various sections of the TV receiver were demodulated and the curve observed on an oscil-

loscope. Because of the relative bandwidths, the tuner response is least critical.

Some reference frequencies are identified to show the importance of proper alignment. Notice that the chroma frequencies are on the slope of the i-f response curve. This area is the most critical because improper i-f alignment in this area will affect the amplitude and shape of the chroma response curve and this in turn affects color picture quality.

Notice that the chroma information is located on a constant-amplitude portion of the transmitted television spectrum. Notice that the relative amplitudes of the chroma information are modified by passing through the tuned circuits of the television receiver tuner and i-f amplifiers. This is shown by reference to the overall i-f response curve. Notice that the signal information at the upper end of the chroma frequency range (4.08 MHz) is reduced in amplitude with respect to the signal level at the lower end of the chroma frequency range (3.08 MHz). To compensate for this frequency-versus-amplitude characteristic of the overall i-f response curve, a chroma takeoff coil is used between the i-f output and the bandpass amplifier of the chroma portion of the receiver. The chroma takeoff coil is tuned to the upper end of the chroma frequency range, usually 4.08 MHz and provides a response as shown in Figure 28. This compensates for the amplitude-versus-frequency characteristic of the chroma portion of the overall i-f response curve. The result of combining the response of the i-f curve and the response of the chroma takeoff coil is to produce a flat

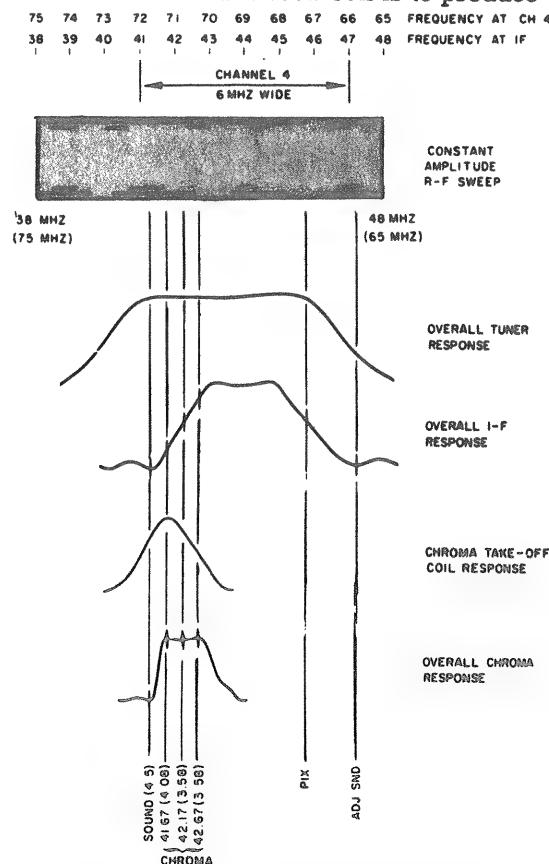


Figure 28. Television Response Curves Obtained Using Sweep-Frequency Technique

overall response in the chroma frequency range (3.08 MHz to 4.08 MHz). The resultant signal is then applied to the bandpass amplifier which has the response indicated by the overall chroma response curve.

Alignment of the chroma takeoff coil is sometimes specified as a separate step in manufacturer's test procedures. In other procedures, adjustment of the chroma takeoff coil is performed together with the adjustment of the bandpass transformer.

SWEEP ALIGNMENT METHODS

The best method of checking alignment and determining which stages require alignment is to inject an r-f sweep frequency signal at the tuner antenna terminals. The agc bias line must be clamped by application of bias or grounding the agc line. The outputs of the i-f and chroma circuits are then observed on an oscilloscope and compared to the manufacturer's recommended response curve.

The technician can then decide which portions of the receiver require alignment. For example, if the i-f response is satisfactory but the chroma response is not, then the problem is between the video detector output of the i-f strip and the output of the bandpass amplifier. If the i-f response and the chroma response are poor then it is most likely that the i-f requires touch-up, particularly if the response is poor on the slope affecting chroma response.

The r-f portion of the tuner seldom creates an alignment problem because the passband is so much greater than that of the i-f section; however, the mixer output circuit, which is located on the tuner,

may require attention. This is part of the tuned matching network between the tuner and the first i-f stage. A separate prealignment procedure is given for the link circuits by some manufacturers.

Once the deficient portion of the receiver is determined, an alignment check of that section can be performed. The alignment procedures vary with manufacturers. Some suggest signal combinations at the tuner antenna terminals which can generate i-f and video sweep frequencies in the receiver so that overall alignment can be done by selecting the right combination of input signals. One way of doing this is to first connect an r-f sweep generator for i-f alignment. After this is complete, the picture carrier frequency for the channel being used is selected and this is modulated by a video sweep signal (this is the VSM, or video sweep modulation method). This video sweep modulation is demodulated at the video detector of the TV receiver and applied to the chroma bandpass circuits for the alignment of these stages.

Other manufacturers recommend an i-f sweep frequency injected at the mixer grid (or base, if transistorized) for i-f alignment. The i-f picture carrier frequency (45.75 MHz) is then modulated with

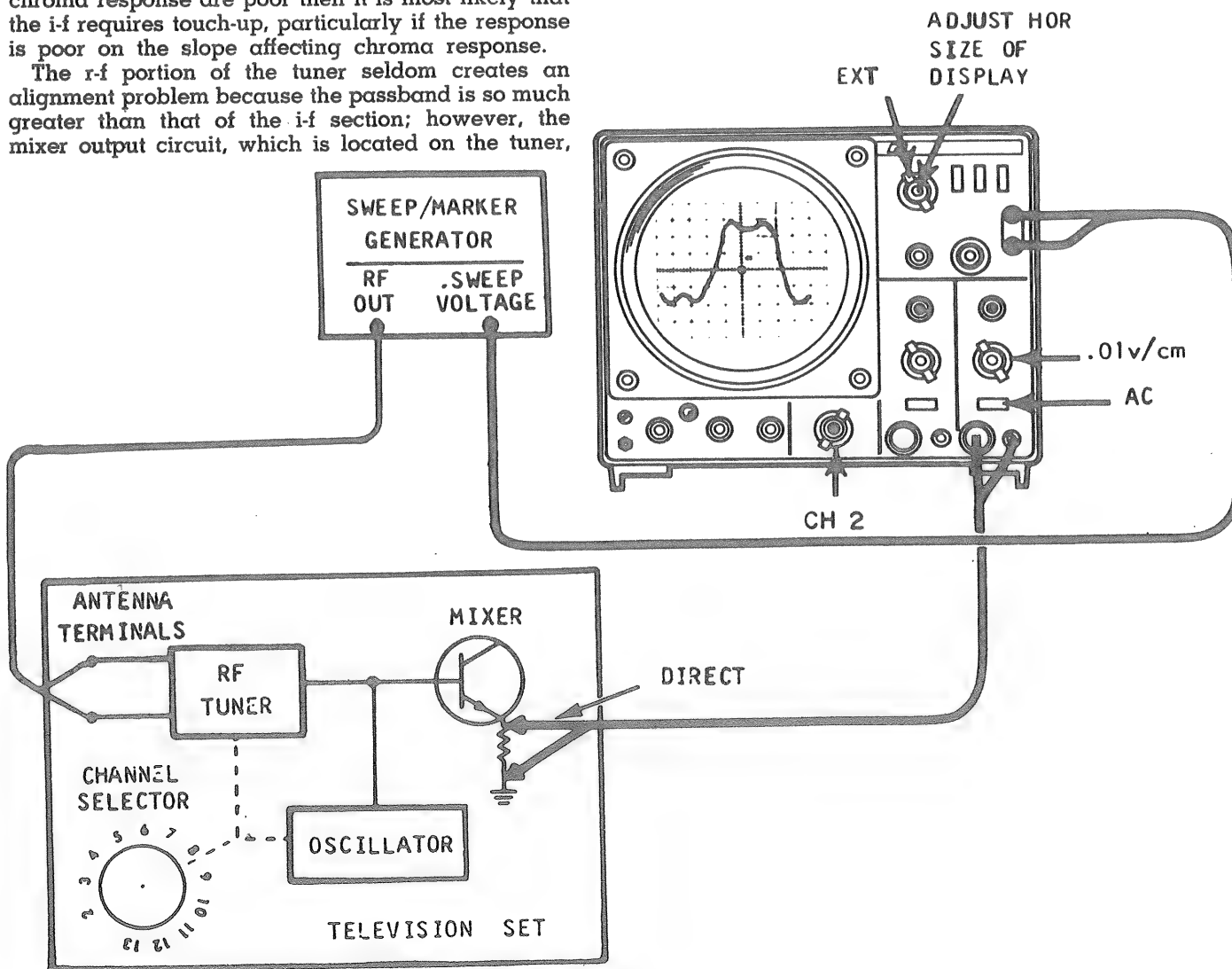


Figure 29. Typical Tuner Alignment Set-Up

a video sweep voltage (VSM again). As before this is detected at the video detector of the TV receiver and the recovered sweep voltage is used for the chroma circuit alignment.

Another method is to first video-sweep align the chroma circuits directly. The i-f is then aligned and then video sweep modulation of the i-f pix frequency (45.75 MHz) is used to check the combined effect on the chroma response of i-f alignment and chroma alignment. Usually a touch-up of the chroma circuits is necessary to obtain the desired final overall chroma response.

In conjunction with i-f alignment, practically all manufacturers recommend pre-tuning i-f traps by injecting spot frequencies into the i-f (usually at a specified tuner test point). Other procedures outline a prealignment of all tuned circuits in the i-f before sweep alignment procedures.

In all cases the manufacturer's method is the best for his particular receiver and the manufacturer's service manual is preferred for alignment. SAMS PHOTOFACT procedures are also reliable and in most cases repeat the manufacturer's procedure. If complete realignment of an apparently deficient receiver does not restore the required response, the technician must then consider that a component failure has occurred and must employ standard trouble shooting procedures.

TUNER ALIGNMENT

Refer to Figure 29

1. Connect the output of the sweep generator to the antenna terminals of the television set.

Adjust the sweep generator to sweep one of the TV channels.

2. Tune the TV set to the same channel.
3. Connect the ground clip of the oscilloscope probe directly to the tuner shield to minimize hum pickup. Connect the vertical probe (set to DIRECT) to the tuner test point. The tuner test point is normally the grid of the mixer tube or equivalent, where a demodulated signal is present.
4. Set the vertical controls for maximum sensitivity and operate the sweep generator at low level to avoid overloading the television receiver, which would distort the response curve and provide an erroneous picture of alignment on the oscilloscope screen.
5. The oscilloscope sweep and sweep generator must be in exact synchronization and phase with each other for proper presentation of the response curve. This is easily accomplished for sinusoidal or sawtooth sweep by setting the oscilloscope for external horizontal input and connecting the horizontal sweep voltage from the sweep generator to the external horizontal input terminals on the oscilloscope.
6. Select the marker generator frequencies required to measure the upper and lower response of the tuner.

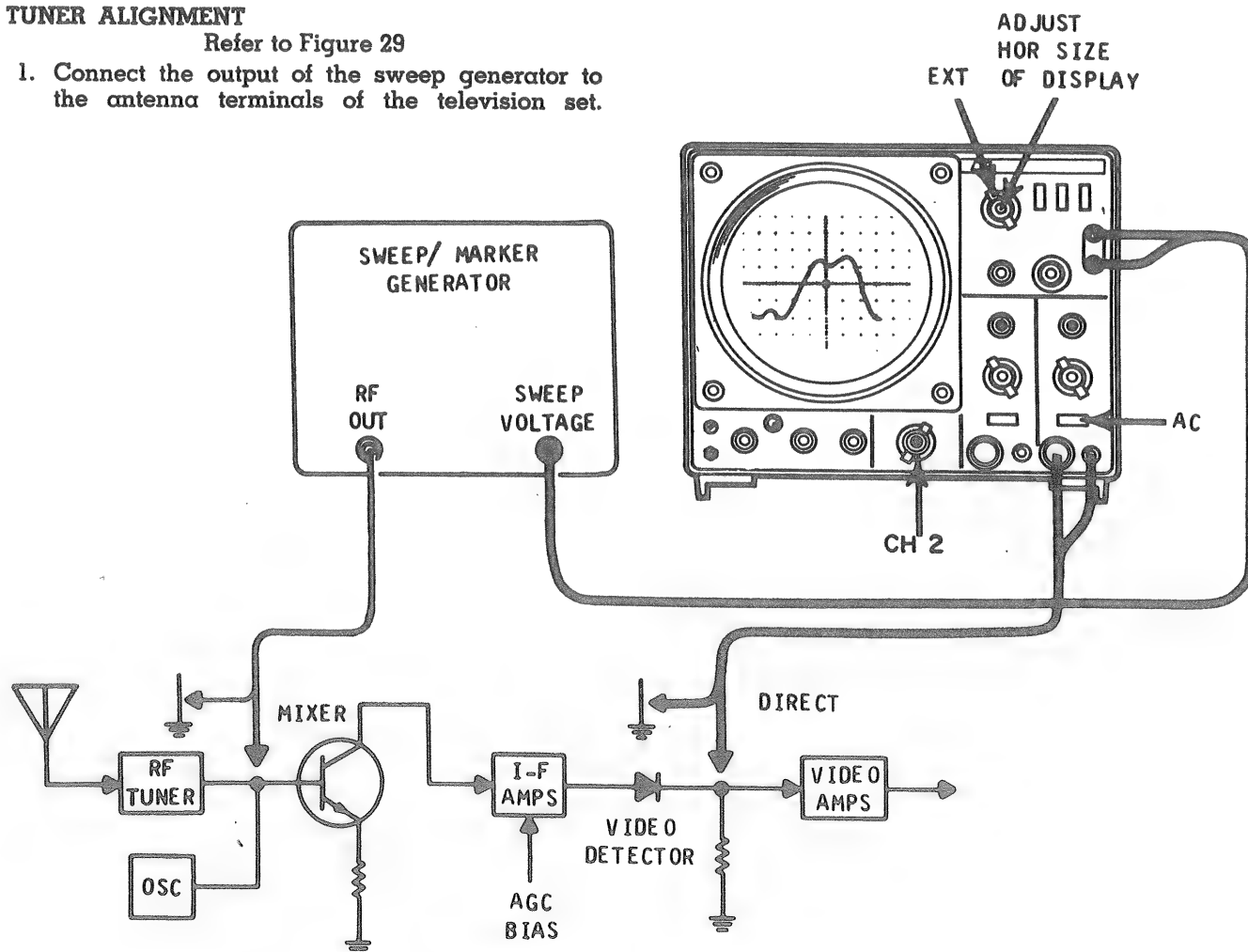


Figure 30. Typical I-F Alignment Set-Up

- The tuner response curve is now displayed on the oscilloscope. See the manufacturer's instructions for the response curve specifications and the necessary adjustments for realignment.

I-F ALIGNMENT

Refer to Figure 30

- Connect the output of the sweep generator to the signal injection point of the mixer. Adjust the sweep generator to sweep the i-f frequency band. (If the tuner has been properly aligned, r-f sweep may be applied at the antenna terminals).
- Synchronize the oscilloscope sweep with the sweep generator as previously described in the TUNER ALIGNMENT procedure.
- Connect the ground clip of the oscilloscope vertical probe to the television set chassis.
- Connect the vertical probe of the oscilloscope to the video detector output.
- Set the vertical gain controls (VOLTS/CM and VARIABLE) for suitable viewing of the response curve.
- Keep the sweep generator output level low to prevent overloading. Follow the manufacturer's recommendations on disabling AGC.
- Select the marker generator frequencies required to check the critical frequencies of interest (see Figure 31). A sweep and marker generator capable of displaying all the markers simultaneously, such as the B & K Model 415, is a big advantage.
- Follow the manufacturer's instructions for evaluating the response curve and making the alignment.

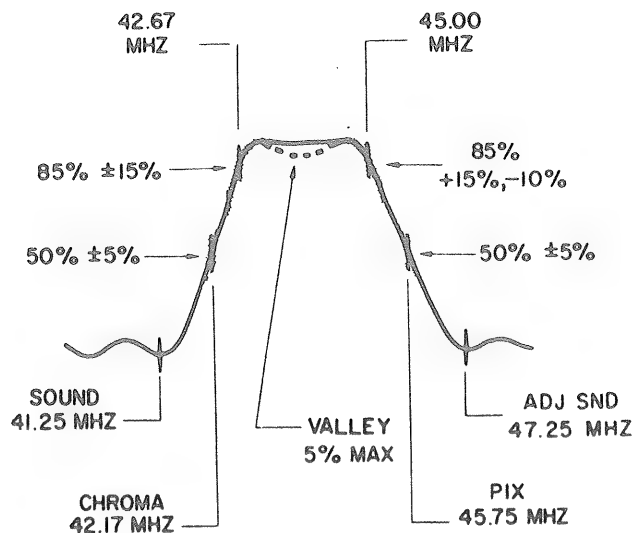


Figure 31. Typical I-F Response Curve Showing Tolerance Ranges of Response Levels

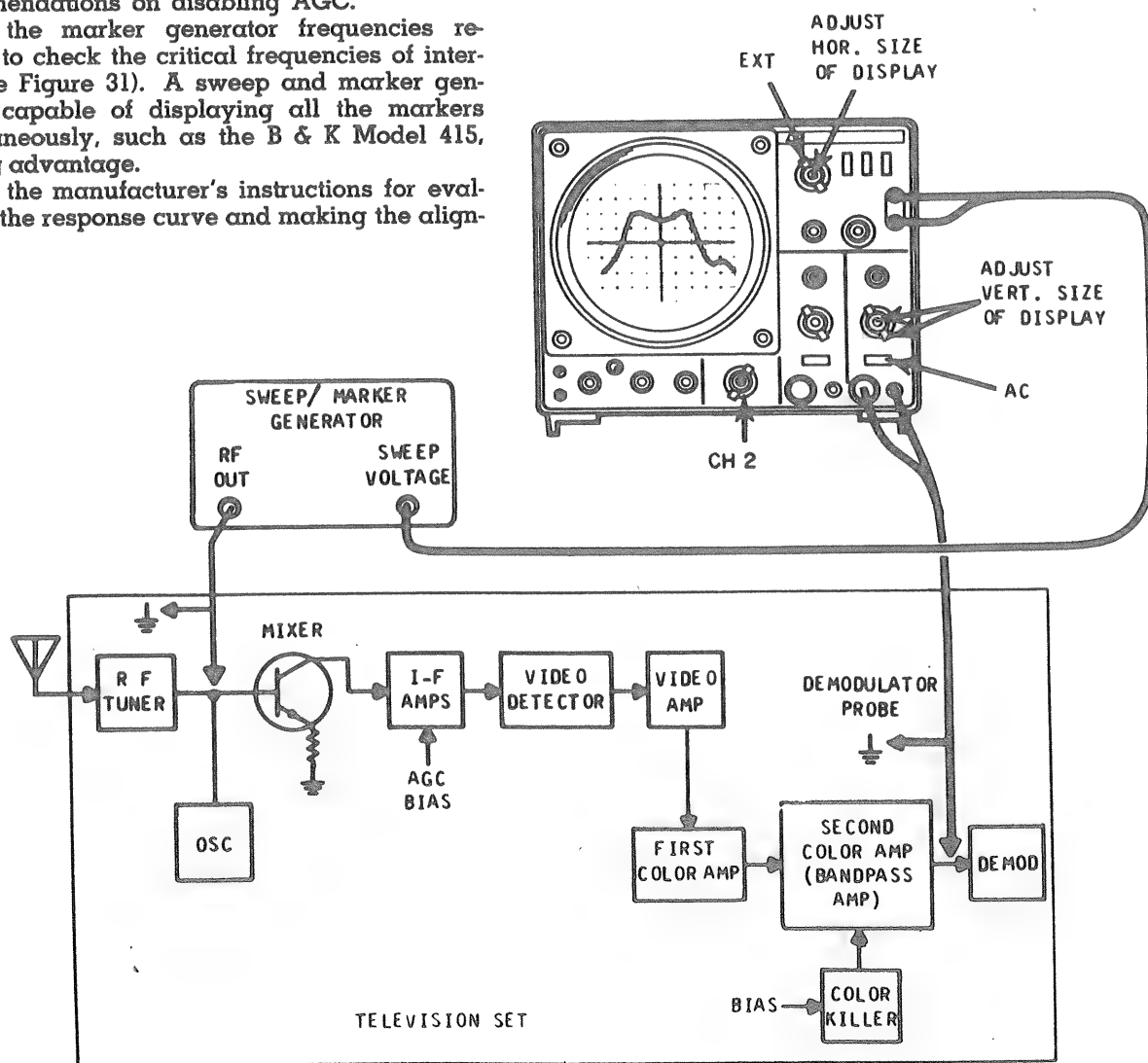


Figure 32. Typical Chroma Alignment Set-Up

CHROMA ALIGNMENT

Refer to Figure 32.

The i-f alignment must be satisfactorily completed before starting this chroma alignment procedure. If direct injection of video sweep is used rather than the i-f sweep injection specified herein, the response curve is altered drastically. Follow the manufacturer's procedure explicitly for such direct injection of video sweep for chroma alignment.

1. Leave the sweep/marker generator and AGC bias connected as for i-f alignment. Set the sweep generator to sweep approximately the 41 to 44 MHz band of frequencies. Use the same i-f injection level that was used for i-f alignment.
2. Apply the proper dc bias to the color killer to enable the color amplifiers (bandpass amplifiers). Refer to the manufacturer's instructions for the correct bias level.
3. Synchronize the oscilloscope sweep as previously described for tuner alignment.
4. Use a demodulator probe for the vertical input to the oscilloscope. Measure the response curve at the input to the demodulators.
5. Set the vertical gain controls of the oscilloscope (VOLTS/CM and VARIABLE) for a convenient viewing size on the screen.
6. A response curve similar to that shown in Figure 33 should be seen. Select the marker generator frequencies of interest. Refer to the manufacturer's instructions for bandpass specifications and alignment procedure.

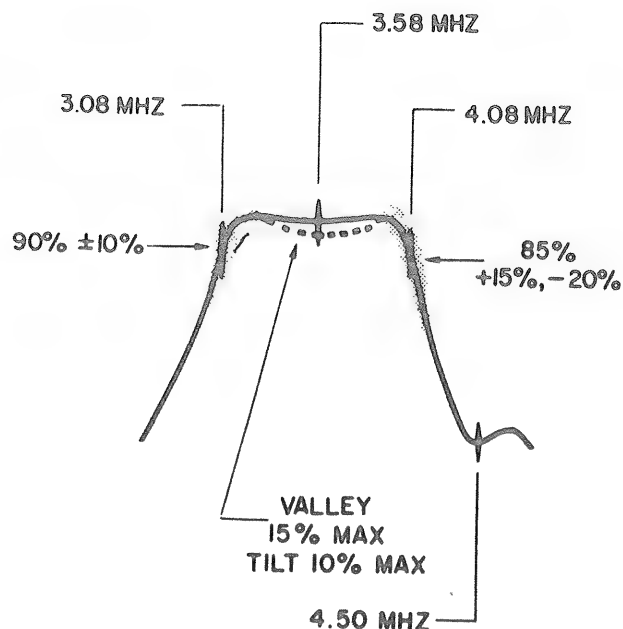


Figure 33. Typical Chroma Response Curve Showing Tolerance Ranges of Response Levels

FM RECEIVER ALIGNMENT

Refer to Figure 34

1. Connect a sweep generator to the mixer input of the FM receiver. Set the sweep generator for a 10.7 MHz centered sweep.
2. Connect the sweep voltage output of the sweep generator to the external horizontal input jack of the oscilloscope and set the oscilloscope controls for external horizontal sweep.
3. Connect the vertical input probe to the demodulator input of the FM receiver.
4. Adjust the oscilloscope vertical and horizontal gain controls for a display similar to that shown in Figure 34. The narrow bandpass is easier to interpret if 5X magnification is used.
5. Set the marker generator precisely to 10.7 MHz. The marker "pip" should be in the center of the bandpass.
6. Align the i-f amplifiers according to the manufacturer's specifications.
7. Move the probe to the demodulator output. The "S" curve should be displayed, and the 10.7 MHz "pip" should appear exactly in the center. Adjust the demodulator according to the manufacturer's instructions so the marker moves equal distances from center as the marker frequency is increased and decreased equal amounts from the 10.7 MHz center frequency.

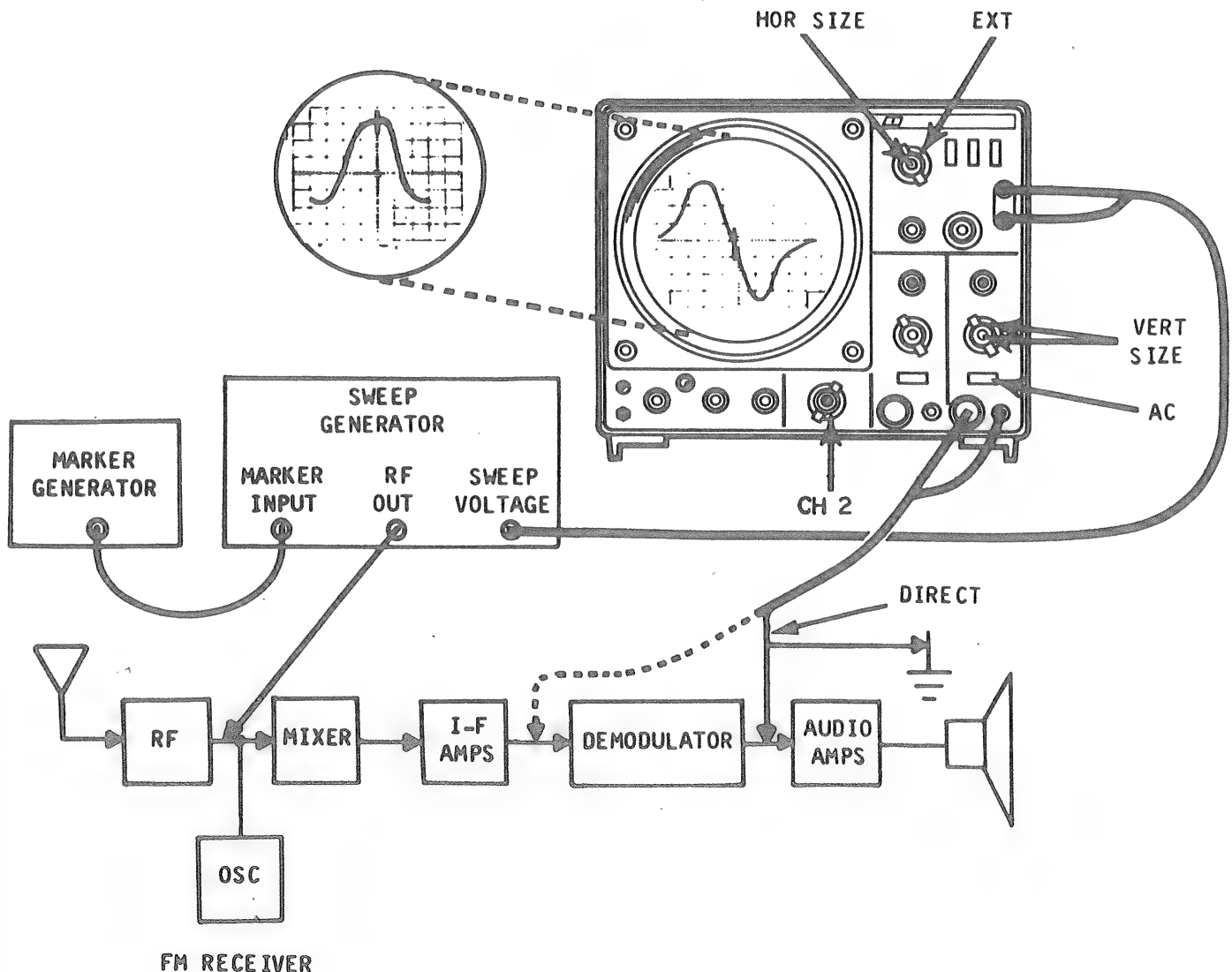


Figure 34. Typical FM Receiver Alignment Set-Up

PHASE MEASUREMENT

Phase measurements may be made with an oscilloscope. Typical applications are in circuits designed to produce a specific phase shift, and measurement of phase shift distortion in audio amplifiers or other audio networks. Distortion due to non-linear amplification is also displayed in the oscilloscope waveform.

A sine wave input is applied to the audio circuit being tested. The same sine wave input is applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting waveform.

To make phase measurements, use the following procedure (Refer to Figure 35)

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.
2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may be observed on the oscilloscope. If the test circuit is overdriven, the sine wave display on the oscilloscope is

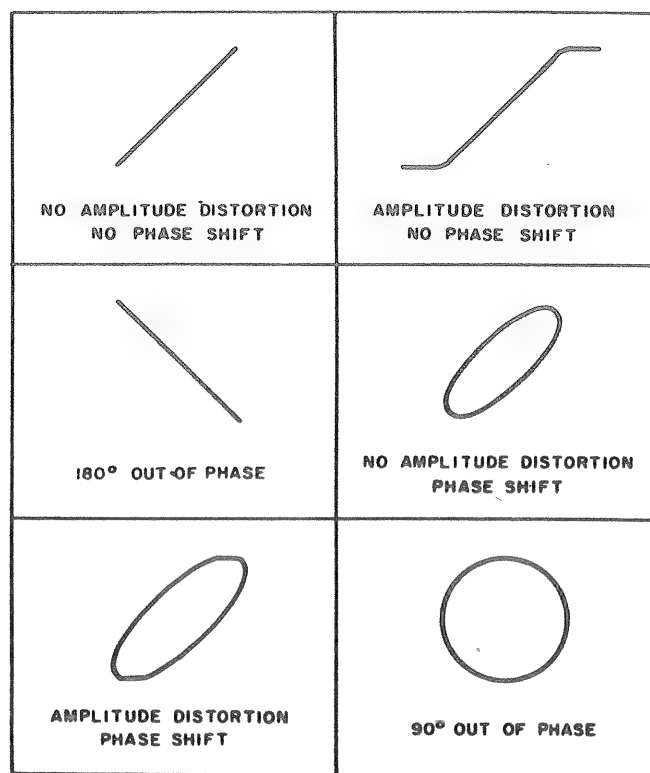


Figure 36. Typical Phase Measurement Oscilloscope Displays

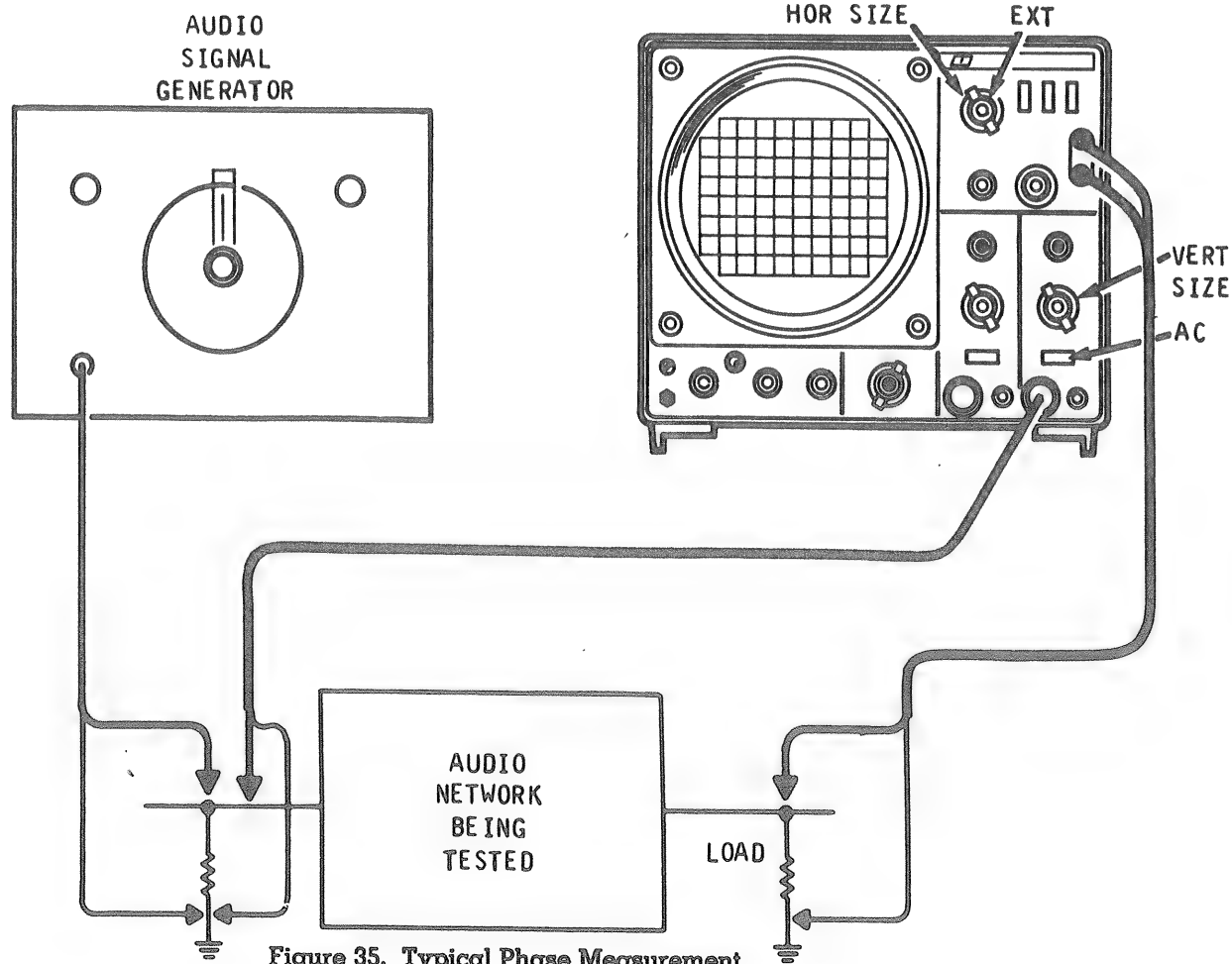
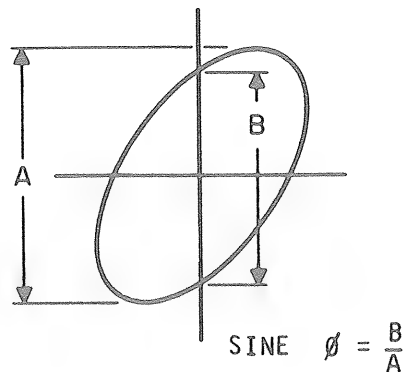


Figure 35. Typical Phase Measurement

- clipped and the signal level must be reduced.
3. Connect an external horizontal input cable from the output of the test circuit to the EXT SYNC/HOR jack of the oscilloscope.
 4. Set the SWEEP TIME/CM control to EXT for external horizontal sweep.
 5. Connect the V INPUT probe to the input of the test circuit. (The input and output test connections to the vertical and horizontal oscilloscope inputs may be reversed. Use the higher vertical gain of the oscilloscope for the lower level signal.)
 6. Adjust the vertical and horizontal gain controls for a suitable viewing size.
 7. Some typical results are shown in Figure 36. If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is at a 45° angle. A 90° phase shift produces a circular oscilloscope pattern.



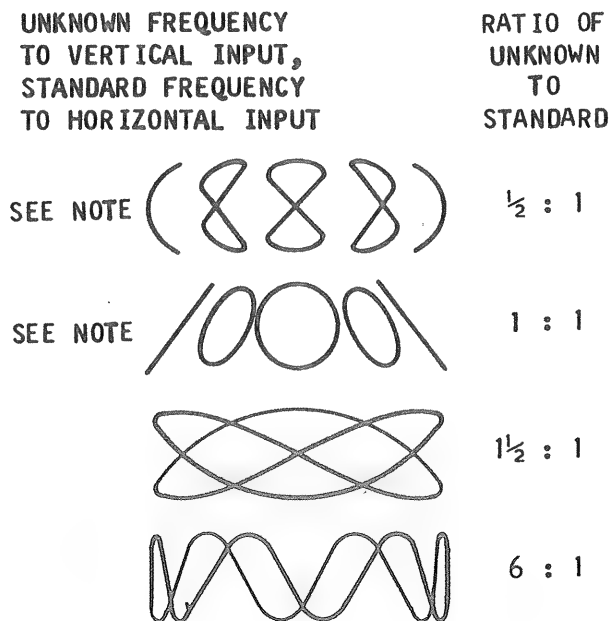
WHERE ϕ = PHASE ANGLE

Figure 37. Phase Shift Calculation

Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Figure 37.

FREQUENCY MEASUREMENT

1. Connect the sine wave of known frequency to the EXT SYNC/HOR jack of the oscilloscope and set the SWEEP TIME/CM control to EXT. This provides external horizontal input.
2. Connect the vertical input probe to the unknown frequency.
3. Adjust the vertical and horizontal size controls for a convenient, easy-to-read size of display.
4. The resulting pattern, called a Lissajous pattern, shows the ratio between the two frequencies. See Figure 38.



NOTE: ANYONE OF THESE FIGURES DEPENDING
UPON PHASE RELATIONSHIP

Figure 38. Lissajous Waveforms Used for Frequency Measurement

SQUARE WAVE TESTING OF AMPLIFIERS

INTRODUCTION

A square wave generator and a low distortion oscilloscope, such as this instrument, can be used to display various types of distortion present in electronic circuits. A square wave of a given frequency contains a large number of odd harmonics of that frequency. If a 500 Hz square wave is injected into a circuit, frequency components of 1.5 KHz, 2.5 KHz, 3.5 KHz, are also provided. Since vacuum tubes and transistors are non-linear, it is difficult to amplify and reproduce a square wave which is identical to the input signal. Interelectrode capacitances, junction capacitances, stray capacitances as well as limited device and transformer response are a few of the factors which prevent faithful reproduction of a square wave signal. A well designed amplifier can minimize the distortion caused by these limitations. Poorly designed or defective amplifiers can introduce considerable distortion to the point where their performance is unsatisfactory.

As stated before, a square wave contains a large number of odd harmonics. By injecting a 500 Hz sine wave into an amplifier, we can evaluate amplifier response at 500 Hz only, but by injecting a square wave of the same frequency we can determine how the amplifier would respond to input signals from 500 Hz up to the 15th or 21st harmonic.

The need for square wave evaluation becomes apparent if we realize that some audio amplifiers will be required during normal use to pass simultaneously a large number of different frequencies. With a square wave, we have a controlled signal with which we can evaluate the input and output quality of a signal of many frequencies (the har-

monics of the square wave) which is what the amplifier sees when amplifying complex waveforms of musical instrument or voices.

The square wave output of the signal generator must be extremely flat so that it does not contribute to any distortion that may be observed when evaluating amplifier response. The oscilloscope vertical input should be set to DC as it will introduce the least distortion, especially at low frequencies. When checking amplifier response, the frequency of the square wave input should be varied from the low end of the amplifier bandpass up toward the upper end of the bandpass; however, because of the harmonic content of the square wave, distortion will occur before the upper end of the amplifier bandpass is reached.

It should be noted that the actual response check of an amplifier should be made using a sine wave signal. This is especially important in limited bandwidth amplifiers (voice amplifiers). The square wave signal provides a quick check of amplifier performance and will give an estimate of overall amplifier quality. The square wave will also reveal some deficiencies not readily apparent when using a sine wave signal. Whether a sine wave or square wave is used for testing the amplifier, it is important that the manufacturer's specifications on the amplifier be known in order to make a better judgment of its performance.

TESTING PROCEDURE

Refer to Figure 39.

1. Connect the output of the square wave generator to the input of the amplifier being tested.
2. Connect the vertical test probe of the oscillo-

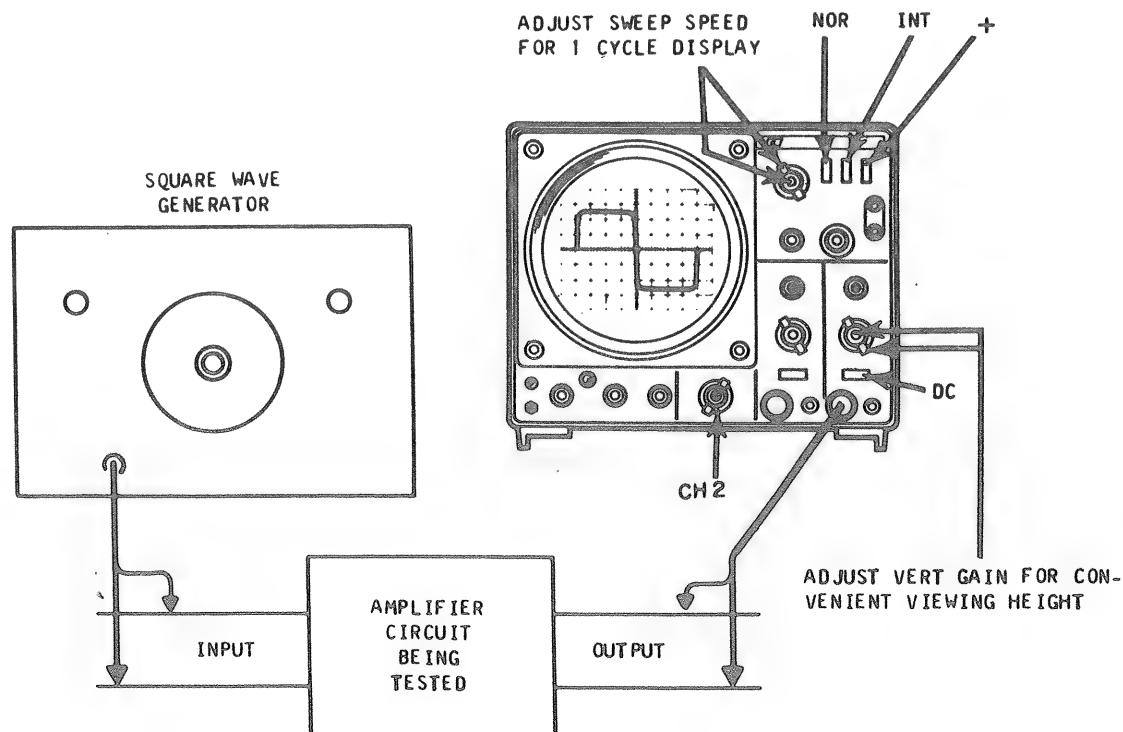


Figure 39. Equipment Set-Up for Square Wave Testing of Amplifiers

- scope to the output of the amplifier being tested.
3. If the dc component of the circuit being tested is sufficiently low to allow both the ac and dc component to be viewed, use the DC position of the AC-GND-DC switch. However, the AC position may be used without affecting the results except at very low frequencies (below 5 Hz).
 4. Adjust the vertical gain controls for a convenient viewing height.
 5. Using INT sync and AUTO triggering, adjust the sweep time controls for one cycle of square wave display on the screen.
 6. For a close-up view of a portion of the square wave, use the 5X magnification.

ANALYZING THE WAVEFORMS

The short rise time which occurs at the beginning of the $\frac{1}{2}$ cycle is created by the in-phase sum of all the medium and high frequency sine wave components. The same holds true for the rapid drop at the end of the $\frac{1}{2}$ cycle from maximum amplitude to zero amplitude at the 180° or $\frac{1}{2}$ cycle point. Therefore, a theoretical reduction in amplitude alone of the high frequency components should produce a rounding of the square wave corners at all four points of one square wave cycle (See Figure 40).

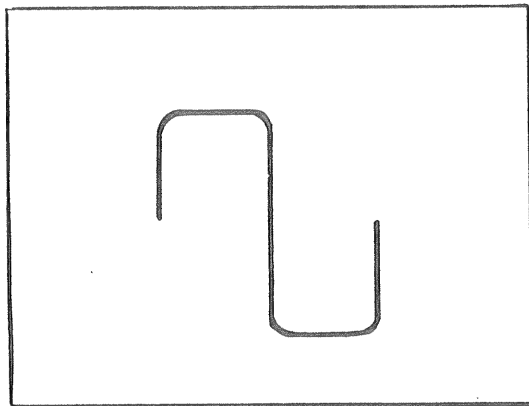


Figure 40. Square Wave Response with High Frequency Losses

Distortion can be classified into three distinct categories:

1. The first is frequency distortion and refers to the change from normal amplitude of a component of a complex waveform. In other words, the introduction in an amplifier circuit of resonant networks or selective filters created by combination of reactive components will create peaks or dips in an otherwise flat frequency response curve.
2. The second is non-linear distortion and refers to a change in waveshape produced by application of the waveshape to non-linear components or elements such as vacuum tubes, an iron core transformer, and in an extreme case a deliberate non-linear circuit such as a clipper network.
3. The third is delay or phase distortion, which is distortion produced by a shift in phase between one or more components of a complex waveform.

In actual practice, a reduction in amplitude of a square wave component (sinusoidal harmonic) is usually caused by a frequency selective network

which includes capacity, inductance or both. The presence of the C or L introduces a difference in phase angle between components, creating phase distortion or delay distortion. Therefore, in square wave testing of practical circuitry, we will usually find that the distorted square wave includes a combination of amplitude and phase distortion clues.

In a typical wide band amplifier, a square wave check accurately reveals many distortion characteristics of the circuit. The response of an amplifier is indicated in Figure 41, revealing poor low frequency response along with overcompensated high frequency boost. A 100 Hz square wave applied to the input of this amplifier will appear as in Figure 42A. This figure indicates satisfactory medium frequency response (approximately 1 KHz to 2 KHz) but shows poor low frequency response. Next, a 1000 Hz square wave applied to the input of this same amplifier will appear as in Figure 42B. This figure displays good frequency response in the region of 1000 to 4000 Hz but clearly reveals the overcompensation at the higher 10 KHz region by the sharp rise at the top of the leading edge of the square wave.

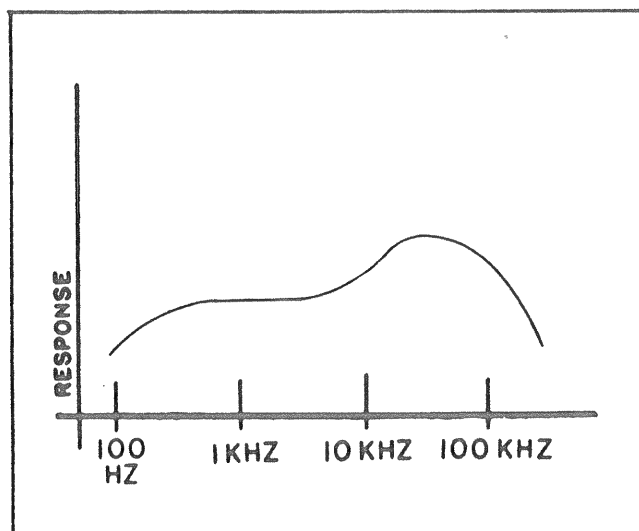


Figure 41. Response of Amplifier Having Poor Low Frequency Response

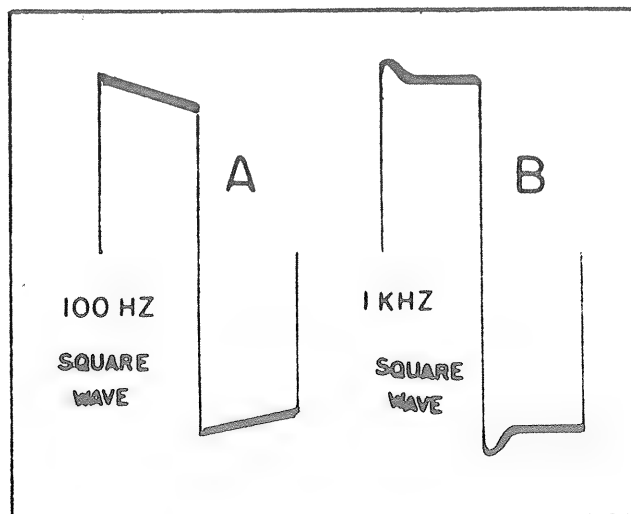


Figure 42. Resultant 100 Hz and 1 KHz Square Waves From Amplifier in Figure 39.

As a rule of thumb, it can be safely said that a square wave can be used to reveal response and phase relationships up to the 15th or 20th odd harmonic or up to approximately 40 times the fundamental of the square wave. Using this rule of thumb, it is seen that wide band circuitry will require at least a two-frequency check to properly analyze the complete spectrum. In the case illustrated by Figure 41, a 100 Hz square wave will encompass components up to about 4000 Hz. To analyze above 4000 Hz and beyond 10,000 Hz, a 1000 Hz square wave should be satisfactory.

Now, the region between 100 Hz and 4000 Hz in Figure 41 shows a rise from poor low frequency response to a flattening out from between 1000 and 4000 Hz. Therefore, we can expect that the higher frequency components in the 100 Hz square wave will be relatively normal in amplitude and phase but that the lower frequency components in this same square wave will be strongly modified by the poor low-frequency response of this amplifier. See Figure 42A.

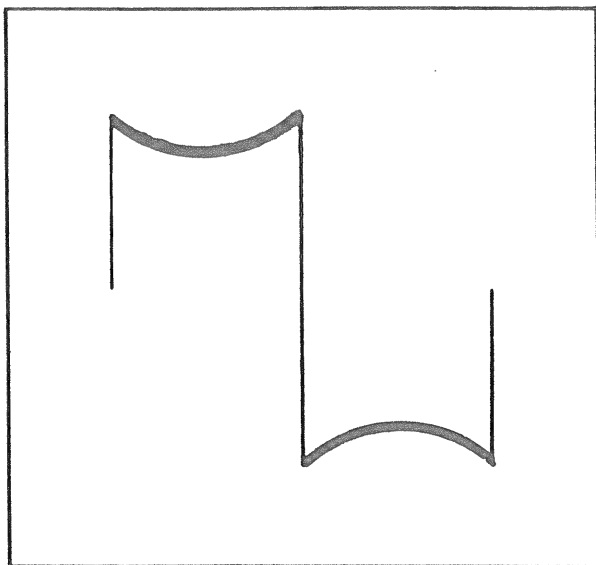


Figure 43. Reduction of Square Wave Fundamental Frequency Component in a Tuned Circuit

If the combination of elements in this amplifier were such as to only depress the low frequency components in the square wave, a curve similar to Figure 43 would be obtained. However, reduction in amplitude to a component, as already noted, is usually caused by a reactive element, causing, in turn, a phase shift of the component, producing the strong tilt of Figure 42A. Figure 44 reveals a graphical development of a similarly tilted square wave. The tilt is seen to be caused by the strong influence of the phase-shifted 3rd harmonic. It also becomes evident that very slight shifts in phase are quickly shown up by tilt in the square wave.

Figure 45 indicates the tilt in square wave shape produced by a 10° phase shift of a low frequency element in a leading direction. Figure 46 indicates a 10° phase shift in a low frequency component in a lagging direction. The tilts are opposite in the two cases because of the difference in polarity of the phase angle in the two cases as can be checked through algebraic addition of components.

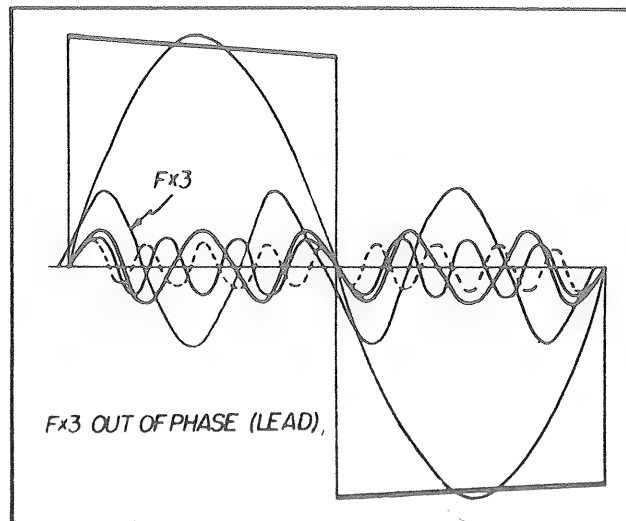


Figure 44. Square Wave Tilt Resulting From 3rd Harmonic Phase Shift.

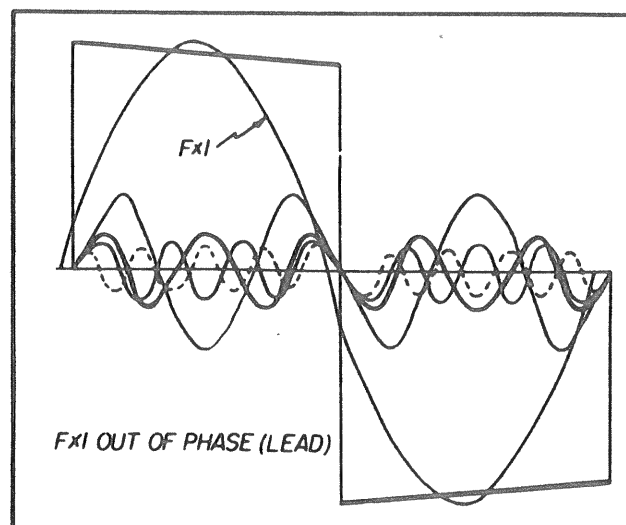


Figure 45. Tilt Resulting From Phase Shift of Fundamental Frequency in a Leading Direction

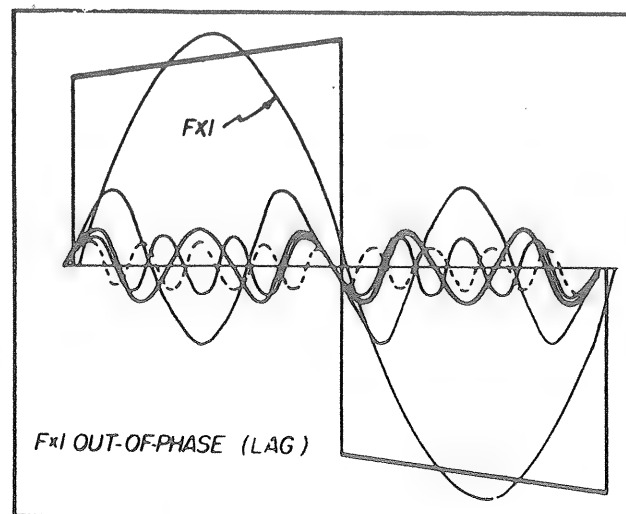


Figure 46. Tilt Resulting From Phase Shift of Fundamental Frequency in a Lagging Direction

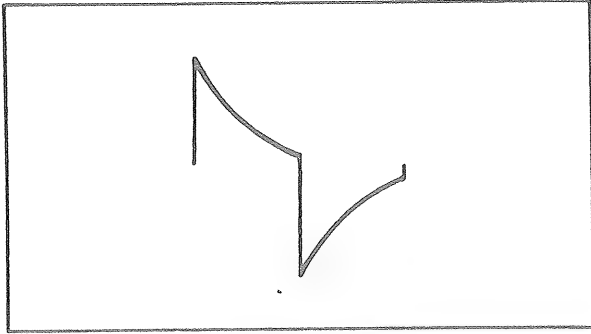


Figure 47. Low Frequency Component Loss and Phase Shift

Figure 47 indicates low frequency components which have been reduced in amplitude and shifted in phase. It will be noted that these examples of low frequency distortion are characterized by change in shape of the flat top portion of the square wave.

Figure 42B, previously discussed, revealed high-frequency overshoot produced by rising amplifier response at the higher frequencies. It should again be noted that this overshoot makes itself evident at the top of the leading edge of the square wave.

This characteristic relationship is explained by remembering that in a normal well-shaped square wave, the sharp rise of the leading edge is created by the summation of a practically infinite number of harmonic components. If an abnormal rise in amplifier response occurs at high frequencies, the high frequency components in the square wave will be amplified disproportionately greater than other components creating a higher algebraic sum along the leading edge.

Figure 48 indicates high frequency boost in an amplifier accompanied by a lightly damped "shock" transient. The sinusoidal type of diminishing oscillation along the top of the square wave indicates a transient oscillation in a relatively high "Q" network in the amplifier circuit. In this case, the sudden transition in the square wave potential from a sharply rising relatively high frequency voltage to a level value of low frequency voltage supplies the energy for oscillation in the resonant network. If this network in the amplifier is reasonably heavily damped, then a single cycle transient oscillation may be produced as indicated in Figure 49.

Figure 50 summarizes the preceding explanations and serves as a handy reference.

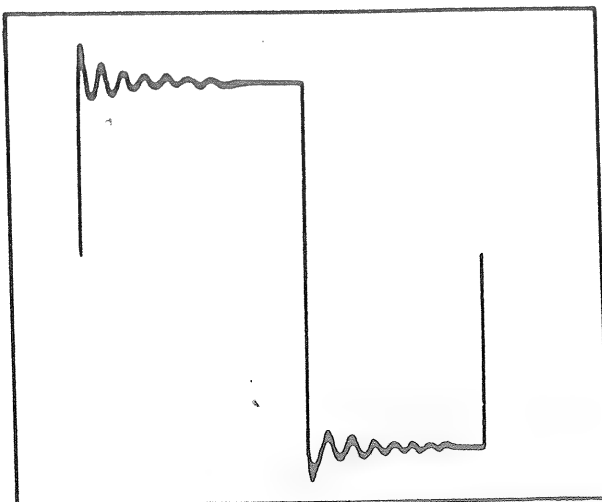


Figure 48. Effect of High Frequency Boost and Poor Damping

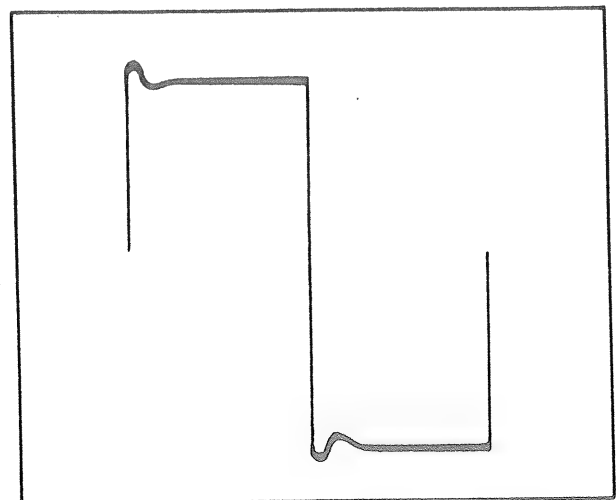


Figure 49. High Frequency Boost and Good Damping

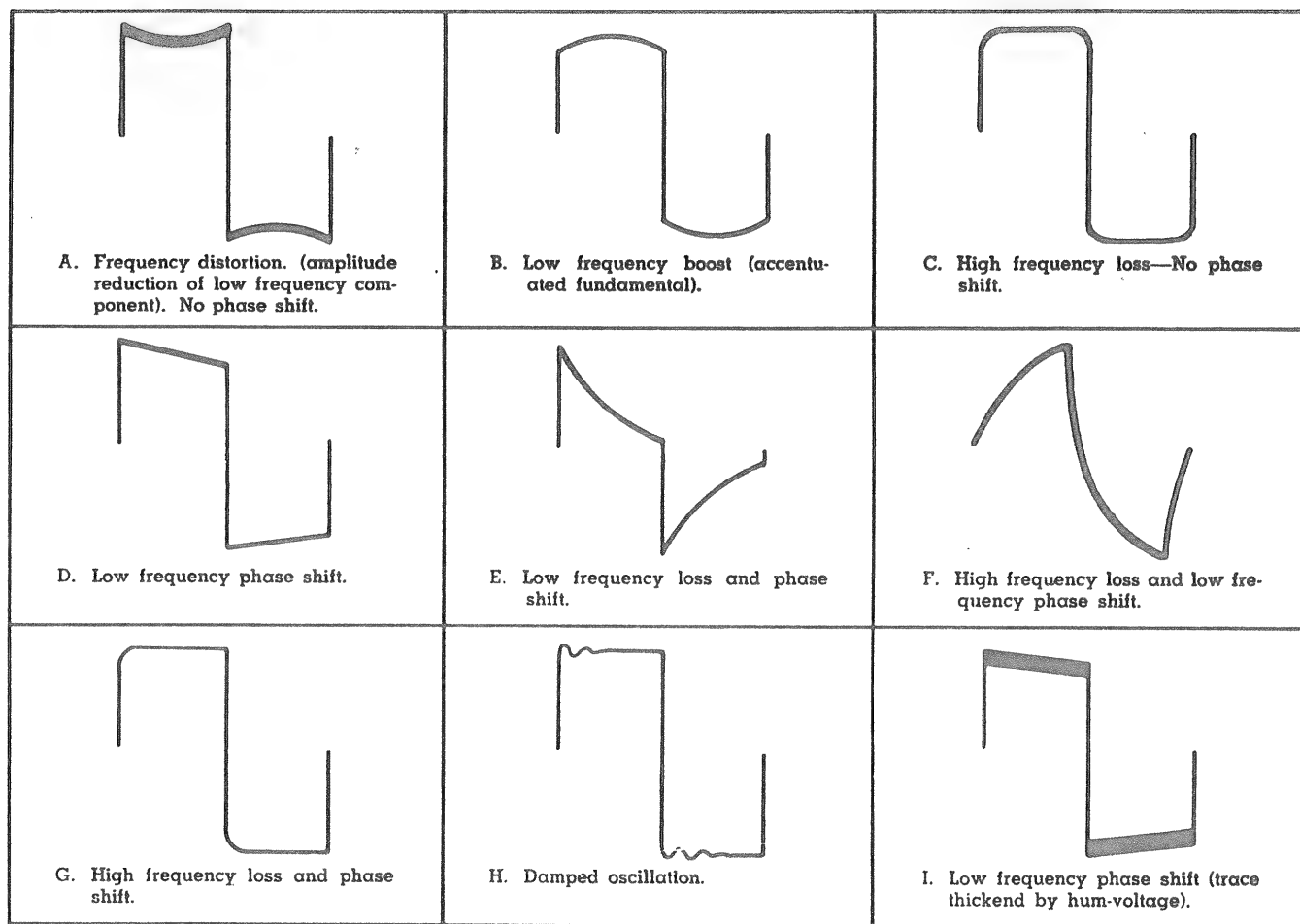


Figure 50. Summary of Waveform Analysis for Square Wave Testing of Amplifiers

CIRCUIT DESCRIPTION

The block diagram of Figure 51 outlines the circuit breakdown of the oscilloscope. Circuit details are obtained by reference to the schematic diagram.

GENERAL

Basically, the oscilloscope is comprised of the following. Two identical vertical preamplifiers are provided, each having its own input attenuator network. The outputs of the vertical preamplifiers can be switched as desired into the main vertical amplifier which in turn drives the vertical plates of the cathode ray tube. The type of switching of the Channel 1 and Channel 2 preamplifiers is determined by the position of MODE switch S105.

Horizontal deflection is provided by the horizontal amplifier. Drive to the horizontal amplifier is furnished either by the sweep generating circuits which have pre-calibrated sweep speeds, or by an external sweep signal which can be applied at the EXT SYNC/HOR jack.

VERTICAL PREAMPLIFIERS

The Channel 1 and Channel 2 vertical preamplifiers are comprised of almost identical circuitry and the circuit operation for both is similar; therefore, the Channel 1 preamplifier will be described in detail. The description applies quite accurately to the Channel 2 preamplifier. Section A of the attenuator switch provides a direct input to the preamplifier (1:1 ratio) and, in addition, selects a series of divider

networks providing ratios of 10:1, 100:1 and 1000:1. Intermediate attenuation ratios of 2 times and 5 times are provided by section B of the attenuator switch. The combined affect of the two attenuator switch sections is to provide the vertical attenuator ratios in a 1-2-5 sequence. Vertical dc balance is provided by VR104. The vernier gain control for Channel 1 is VR105, and vertical position adjustment is provided by VR106. Provision is made for triggering the sweep on the signal applied to the Channel 1 preamplifier. This trigger information is generated by the amplifier network consisting of transistors Q28 thru Q36 inclusive.

The Channel 2 vertical preamplifier is identical to Channel 1 with the following exceptions:

- a. A polarity inverting switch S1 is provided. This enables the user to invert the waveform observed on Channel 2.
- b. No Channel 2 trigger circuitry is provided.

VERTICAL AMPLIFIER

The output of either Channel 1, Channel 2 or both are diode switched into the main vertical amplifier consisting of transistors Q20 thru Q27 inclusive. The push-pull output of transistors Q26 and Q27 is applied to the vertical deflection plates of the CRT.

HORIZONTAL AMPLIFIER

The main horizontal amplifier consists of emitter followers Q16 and Q17 driving output amplifiers

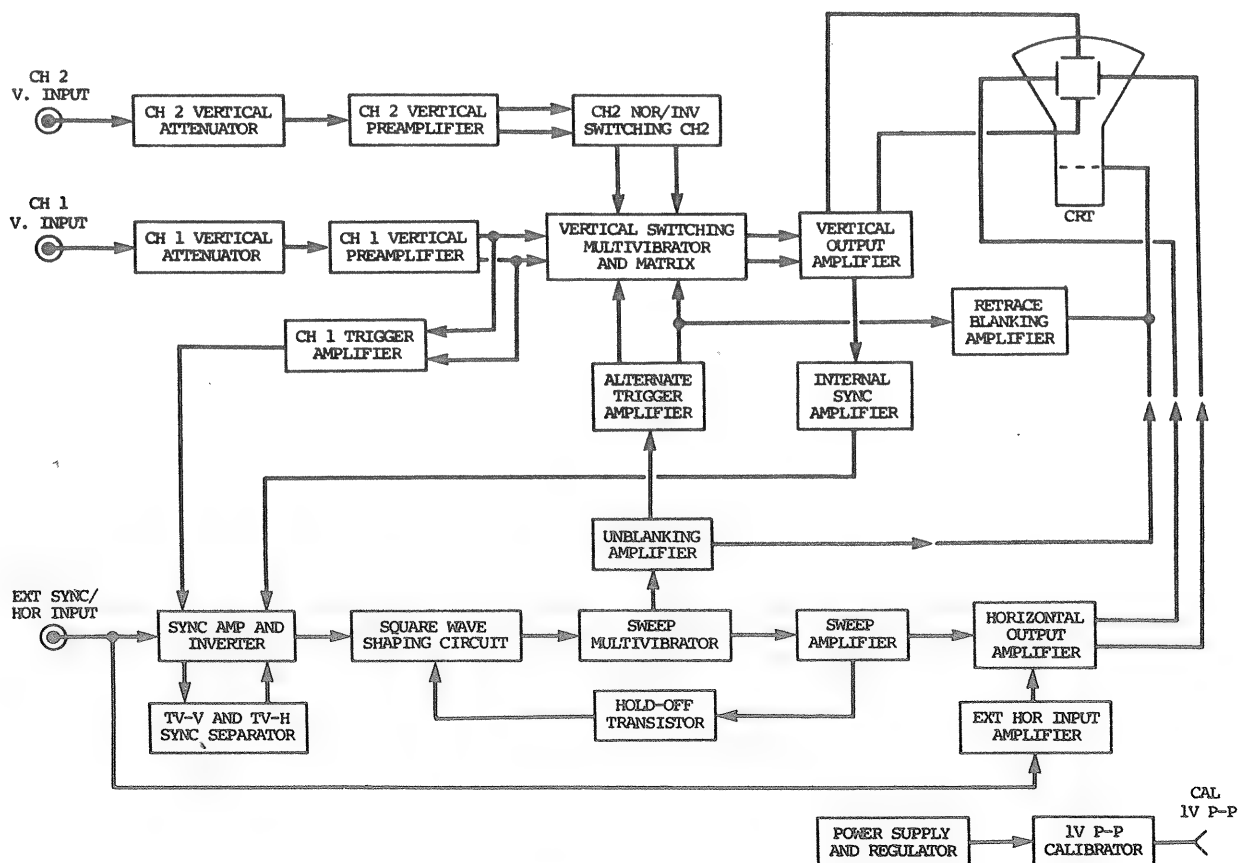


Figure 51. Block Diagram

Q18 and Q19 respectively. The 5X MAG switch S111 is used to increase the output amplifier gain by a factor of five times. Potentiometer VR111 is the «» POS control which shifts the oscilloscope display horizontally by adjusting the dc voltage applied to the base of Q17. Potentiometers VR6, VR7 and VR8 are internal calibration adjustments for horizontal positioning range, horizontal gain adjust and 5X magnification adjustment, respectively. The input to the horizontal amplifier is supplied through SWEEP TIME/CM switch S106. In all but the last position of switch S106, the input is supplied from sweep amplifier Q15 of the horizontal sweep circuits. In the EXT position of S106 the input to the horizontal amplifiers is supplied from transistor Q13, the input to which is furnished from the EXT SYNC/HOR jack.

HORIZONTAL SYNC AND SWEEP CIRCUITS

The sync signal is selected as INT (Internal), CH 1 (Channel 1) or EXT (External) by the TRIGGERING SOURCE Switch. Limiter amplifiers Q1 and Q2 amplify and clip the sync signal supplied through TRIGGERING SOURCE switch S107. This improves the rise time of the sync signal.

The polarity of the sync signal delivered from limiter amplifier Q2 is selected by SLOPE switch S109. Bias to transistors Q1 and Q2 is provided through TRIG LEVEL control VR107 which establishes the sync threshold for the sweep circuit.

TVH AND TVV SYNC SEPERATOR CIRCUITS

To improve the sync capability of this instrument when viewing composite television video information, a sync separator circuit consisting of transistors Q8 and Q9 is provided. This circuit is operative when the TRIGGERING SYNC switch S108 is in the TVH or TVV position. Input to Q8 is supplied from limiter amplifier Q2 through switch S108. Transistor Q8 operates as an impedance transformer to provide a low impedance driving source to the base of Q9. The time constant in the base circuit of Q9 is such that, with signal input applied, Q9 is biased to a near-cutoff condition so that it is driven into conduction only on positive peaks of the input signal. The self bias varies with the level of the incoming signal. The output of Q9 is therefore a series of pulses corresponding to the conduction interval of the transistor.

Because the circuit generates output pulses corresponding to the peak amplitude of input signals, it is ideally suited for generating sync pulses corresponding to the tips of vertical and horizontal pulses of the composite video signal. The sync pulse output of Q9 is applied through switch S108B to the base of Q3 when the TRIGGERING SYNC switch is in the TVH position. When the TRIGGERING SYNC switch is in the TVV position, the horizontal sync information is removed from the composite video signal by integrated capacitor C12 and a sync pulse output corresponding to the tip of the vertical blanking pulse is generated. This is also applied to the base of Q3.

SQUARE WAVE SHAPING CIRCUIT

The square wave shaping circuit is a Schmitt trigger comprised of transistors Q3 and Q4. This circuit delivers a square wave output when the level of its triggering signal is raised to a certain value. The square wave output of this circuit is coupled through a differentiator circuit (C5 and R15) to the base of Q5. When switch S110 is in the AUTO position, the gate multivibrator operates in an astable

mode and is pulled into synchronization by the trigger signal supplied to the base of Q3.

SWEEP CIRCUIT

The differentiated output signal of Q4 is applied to the gate of Q5 which operates as a source follower to drive gate multivibrator transistor Q6. The gate multivibrator consists of transistors Q6 and Q7. The Miller integrating circuit consisting of transistors Q14 and Q15 and the hold off transistor Q10 comprise the dc feedback loop which generates the sweep saw tooth voltage. The gate multivibrator is set at the threshold of operation by use of the STABILITY control. As soon as the multivibrator receives a trigger signal from the square wave shaping signal it inverts the state of its transistors and turns off switching diodes D2 and D3. This allows the time base capacitors in the gate circuit of transistor Q14 to charge at a rate which is determined by the combination of the timing base capacitors and resistors as selected by the SWEEP TIME/CM control. This charging signal is applied through high input impedance FET Q14 to the base of Q15 and the output of this transistor is applied through S106 to the base of horizontal amplifier transistor Q16. The output of Q15 is also applied through the time base capacitors to the base of FET Q14, providing a charging waveform having a high degree of linearity. The output of Q15 is also applied diode D6 to the base of the hold off transistor Q10. Hence, the holdoff circuit feeds back the integrating circuit output to the gate of Q5, causing the conducting states of Q6 and Q7 to remain unchanged until the sweep voltage of the Q15 output reaches a specific level. At this time the conducting states of Q6 and Q7 are reversed, causing diodes D2 and D3 to conduct, thus completing the sweep.

The gating output pulse of Q7 is also applied to transistor Q11 which in turn drives transistor Q12. The amplified output pulse of Q12 is applied to the grid of the CRT and is used to unblank, or gate on, the CRT beam at the beginning of the sweep.

OPERATING MODE SELECTION

Transistors Q38 and Q39 comprise a switching multivibrator which provides the gating information for switching the output of the Channel 1 and Channel 2 preamplifiers into the main vertical amplifier. In the CH1 position of the MODE switch diodes D4 and D5 are reversed biased by the potential applied through diodes D2 and D3. At the same time diodes D7 and D8 are reversed biased allowing diodes D9 and D10 to become forward biased. When this occurs the output signal of the Channel 1 preamplifier is coupled into transistors Q20 and Q21 of the main vertical amplifier. With the MODE switch in the CH2 position, the output diodes of Channel 2 are forward biased and those of Channel 1 are reversed biased, causing only the output of the Channel 2 preamplifier to be coupled to transistors Q20 and Q21. In the CHOP position of the MODE switch, Q38 and Q39 are switched into a free running mode at approximately 140KHz. When this occurs, the Channel 1 and Channel 2 preamplifier outputs are switched at a 140 KHz rate. At relatively low sweep speeds this provides the illusion of 2 continuous traces, one for Channel 1 and one for Channel 2. When the MODE switch is in the ALT position, Q38 and Q39 operate as a bistable multivibrator which

changes state each time a gating pulse is received from Q12 and applied through Q37 to the common input point for Q38 and Q39. When this occurs it causes the output of the Channel 1 preamplifier to be switched to the input of the main vertical amplifier for the duration of one sweep and then the output of the Channel 2 amplifier is switched on for the duration of one sweep.

In the ADD position MODE switch both Q38 and Q39 are turned on, allowing the outputs of both Channel 1 and Channel 2 preamplifiers to be applied simultaneously to the input of Q20 and Q21.

1 V p-p GENERATOR

Transistor Q22 is alternately switched into cutoff and saturation at a 60 hertz rate. The output of this transistor is supplied to the CAL IV PP jack.

MAINTENANCE AND CALIBRATION

WARNING

Voltages as high as 1600 volts are present on the cathode ray tube and in the power supply circuits. Use extreme caution when the cabinet is removed from this instrument.

HOUSING REMOVAL

(See Figure 52)

1. Remove the two screws from the lower rear corners of the housing.
2. Remove the screw on the underside of the housing. This screw is located at the rear center of the housing.
3. With the oscilloscope located on a flat surface, push the chassis forward, applying pressure on the chassis at the cut-out at the rear of the housing. Carefully apply pressure until the front panel flange clears the front of the housing.
4. Supporting the front panel and chassis assembly at the lower edge of the front panel, pull forward until the chassis clears the housing.

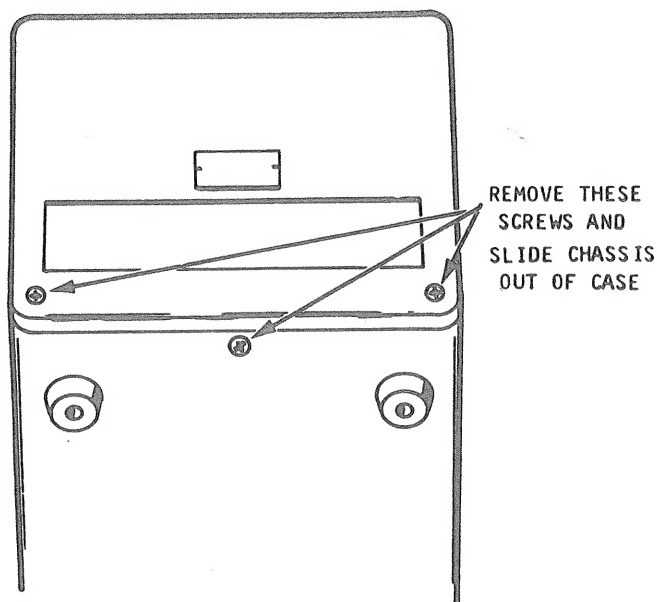


Figure 52.

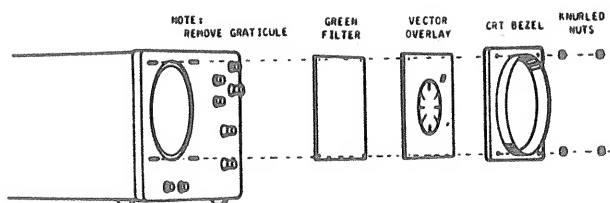


Figure 53.

GRATICULE REMOVAL AND REPLACEMENT

(See Figure 53)

Two bulbs, located behind the bezel illuminate the scale. To replace these bulbs:

1. Remove all four bezel retaining nuts.
2. Lift off the bezel.
3. Lift off the scale

SCALE ILLUMINATION LAMP REPLACEMENT

1. Remove chassis from case.
2. Remove bezel and graticule.
3. Gently push on bulb from front of unit until it is free of retaining grommet.
4. Unsolder wires and replace bulb.

CRT POSITIONING

Checking proper positioning as follows:

1. Rotate the MODE switch to CH1 and set the CH1 AC-GND-DC switch to GND.
2. Set the CH1 TRIG LEVEL control fully counter-

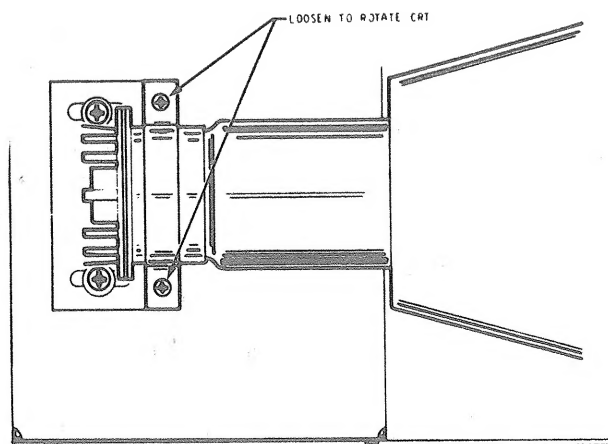


Figure 54.

clockwise, AUTO STABILITY fully clockwise and SWEEP TIME/CM to 1ms.

3. Adjust intensity and FOCUS controls for a fine trace on the CRT.
4. Adjust CH1 \blacktriangleleft POSition control to place trace in center of CRT.
5. The trace should align exactly with the center horizontal marker scale.

If the trace on the CRT is not in alignment with the horizontal scale, correct it as follows:

1. Remove the oscilloscope chassis from the case as outlined previously.
2. Loosen the screws in the mounting clamps over the neck of the CRT. (See Figure 54).
3. Turn CRT for proper alignment of trace with scale.
4. Tighten CRT clamping screws. Tighten evenly

to keep CRT properly positioned.

CLEANING AND REPAIRING

As with any piece of equipment using high voltages, the electrical charge tends to capture some dust particles from the air. An occasional cleaning to remove the dust accumulation will allow components to operate cooler and give longer life. Use a soft brush and be careful not to disturb components.

If the oscilloscope does not operate properly, double check that all operator's controls have been properly set. If trouble persists, the malfunction may be isolated by conventional troubleshooting techniques including voltage and resistance checks. Compare voltage readings with those on the schematic diagram. Please refer to the Warranty Service instructions on the last page of this manual if the reason for the malfunction cannot be determined.

CALIBRATION ADJUSTMENTS

The calibration adjustments outlined here are those which can be performed with a minimum of specialized test equipment. Additional internal adjustments of frequency compensation and horizontal sweep linearity should not be attempted without complete service information and specified test equipment. Requests for complete service information for this oscilloscope should be addressed to:

Service Department
B+K Precision

6470 West Cortland St.

Chicago, Illinois 60635

The internal adjustments outlined in the calibration procedure can be located by reference to Figure 55 and Figure 56.

ASTIGMATISM ADJUSTMENT

(Performed using Channel 1)

1. Set SWEEP TIME/CM control to EXT.
2. Adjust \blacktriangleleft POS and CH1 \blacktriangleleft controls to position spot in center of screen.
3. Adjust INTENSITY control over its full range. Note that the dot disappears in the last 90 degrees of counterclockwise rotation.
4. Set INTENSITY control to maximum clockwise position and set FOCUS control to midrange.
5. Adjust ASTIG control (front panel screwdriver adjustment) for round spot.
6. Rotate FOCUS control over its full range and note that the spot remains round and decreases to minimum size in the center of its adjustment range.

CH 1 AND CH 2 DC BALANCE

1. Adjust controls to obtain horizontal trace (Channel 1 or Channel 2).
2. Adjust CH1 or CH2 \blacktriangleleft POS control to center the sweep vertically on the CRT screen.
3. Rotate the VARIABLE control from maximum counterclockwise to maximum clockwise while observing the trace.
4. If the trace moves vertically more than 5 millimeters (5 mm) while performing Step 3, adjust the CH1 or CH2 DC BAL (front panel screwdriver adjustment) so that the vertical movement of the trace does not exceed 5 mm while performing Step 3.

CH1 AND CH2 VERTICAL POSITION ADJUSTMENT (Refer to Figure 55)

1. Set the \blacktriangleleft POS control (CH1 and CH2) to the mechanical center of its adjustment range.
2. With a horizontal trace on the CRT screen (Channel 1 or Channel 2), adjust VR7 (Channel 1) or VR3 (Channel 2) until the horizontal trace is positioned on the centerline of the graticule on the CRT screen.
3. Turn the \blacktriangleleft POS control (CH1 or CH2) clockwise and counterclockwise from its mechanical center position and observe that the trace moves up and down, respectively, at least 4 centimeters (4 squares) from the graticule center line.
4. Check that the direction of movement of the Channel 2 trace is reversed when the CH2 \blacksquare INV/ \blacksquare NOR switch is in the \blacksquare INV position and the CH2 \blacktriangleleft POS control is adjusted as in the previous paragraph.

HORIZONTAL POSITION ADJUSTMENT (Figure 56)

1. Set \blacktriangleleft POS control to center of its mechanical adjustment range.
2. Set SWEEP TIME/CM switch to EXT.
3. Adjust VR2 (horizontal center adjustment) so that the spot on the oscilloscope is horizontally positioned at the center of the CRT.
4. Turn the \blacktriangleleft POS control clockwise and counterclockwise to determine that the spot moves to the right and left, respectively. The amount of deflection obtained in both directions should be a minimum of 4 cm.

VERTICAL GAIN ADJUSTMENT (Refer to Figure 55)

The following adjustments should be attempted only if a square wave generator with one percent, or better, amplitude accuracy, or a reference oscilloscope having vertical calibration accuracy of better than one percent is available.

1. Set CH1 and CH2 VOLTS/CM switches to .01 and set CH1 and CH2 VARIABLE controls to full clockwise (CAL) position.
2. Set CH1 and CH2 AC-GND-DC switches to DC.
3. Apply 1 KHz square wave of 50 mV peak-to-peak directly to the CH1 V input connector (MODE switch in CH1 position). Do Not use a probe.

4. Adjust VR8 (See Figure 55) for Channel 1 gain adjustment for exactly 5 cm, (five large divisions) of vertical deflection on the CRT screen.
5. Apply the 1 KHz 50 mV peak-to-peak square wave to the CH2 V INPUT jack (MODE switch in CH2 position) and adjust VR4 for 5 cm vertical deflection of the Channel 2 waveform display.
6. Adjust 1 KHz input to 100 mV peak-to-peak and set CH1 VOLTS/CM control to .02.
7. Adjust VR5 (1/2 ATT ADJ, CH1) for 5 cm vertical deflection.
8. Connect 1 KHz, 100 mV peak-to-peak signal to CH2 V INPUT with CH2 VOLTS/CM control at .02.
9. Adjust VR1 (1/2 ATT ADJ, CH2) for 5 cm vertical

deflection.

10. Adjust 1 KHz signal to 250 mV peak-to-peak and apply first to CH1 V INPUT and then to CH2 V INPUT and adjust VR6 (1/5 ATT ADJ, CH1) and VR2 (1/5 ATT ADJ, CH2), respectively, for 5 cm vertical deflection on the CRT.

1V p-p CALIBRATION ADJUSTMENT

The following procedure can be performed if the vertical calibration adjustments have been performed as outlined in this section.

1. Set the CH1 VOLTS/CM control to ".2" and the CH1 VARIABLE control to CAL.
2. Make a direct connection from the CAL 1 V pp jack to the CH1 V INPUT jack.
3. Adjust VR9 (Figure 56) for exactly 5 cm vertical deflection.

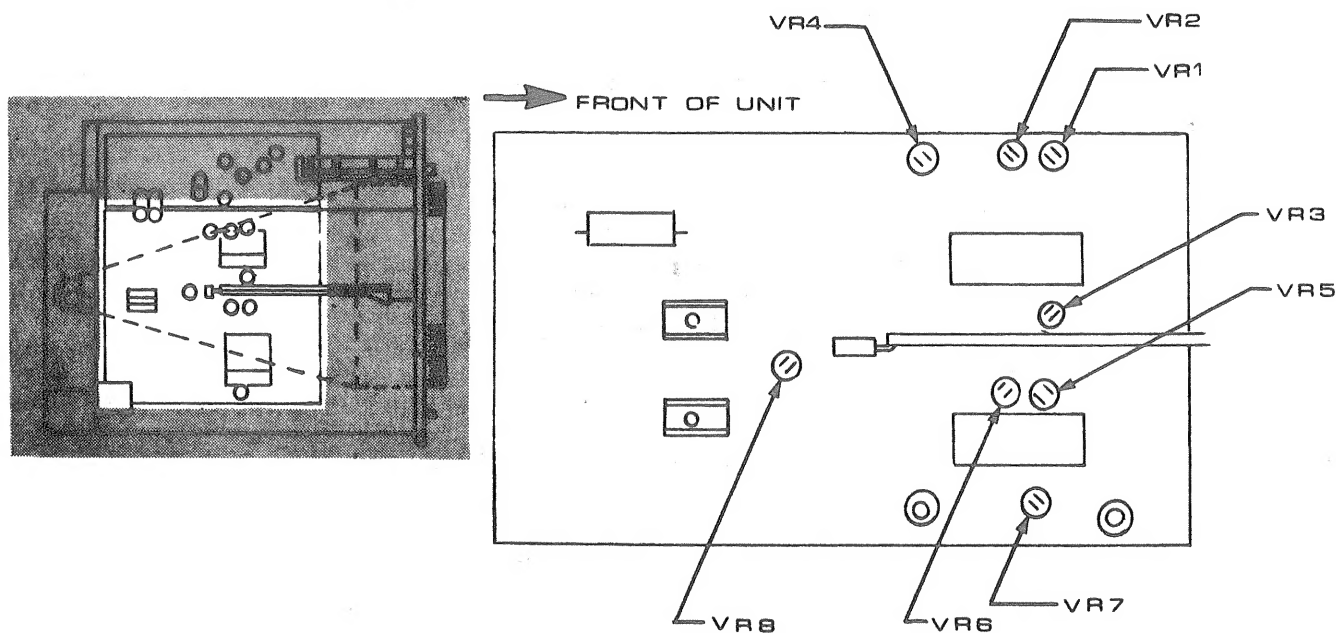


Figure 55.

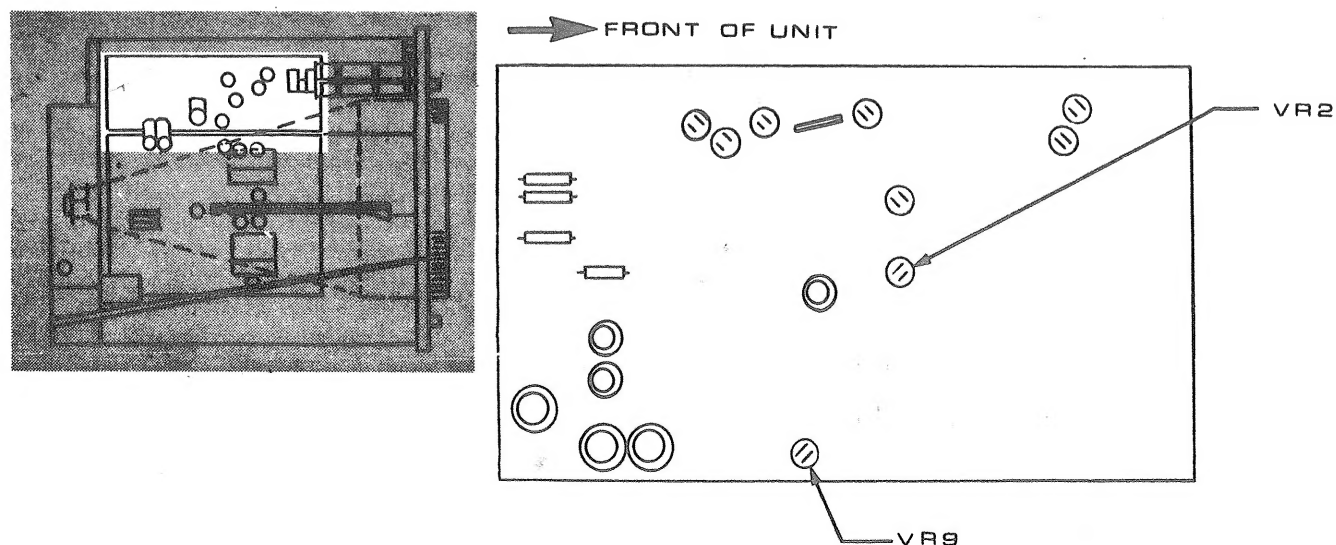


Figure 56.